60
A90B
66

RALPH B. PECK
13 TALBOT LAB
URBANA, ILL.

PROCEEDINGS OF THE AMERICAN RAILWAY ENGINEERING ASSOCIATION

(Engineering Division, Association of American Railroads)

CONTENTS, VOLUME 66

(For detailed index, see Bulletin 593, page 819)

Page

Bulletin 587, September–October 1964
Man–Machine Communication in Civil Engineering 1
Construction of the Great Slave Lake Railway 31
An Industrial Engineering Study of a Freight Car Repair Facility 49
Epoxy Resin Coatings on Steel and Concrete 59
Corrosion of Deck Plates After Five Years of Exposure 73

Bulletin 588, November 1964 (Reports of Committees)
9—Highways 89
13—Water, Oil and Sanitation Services 99
14—Yards and Terminals 127
16—Economics of Railway Location and Operation 143
20—Contract Forms 153
25—Waterways and Harbors 167
30—Impact and Bridge Stresses 183

Bulletin 589, December 1964 (Reports of Committees)
6—Buildings 187
3—Ties and Wood Preservation 225
11—Engineering and Valuation Records 231
28—Clearances 245
22—Economics of Railway Labor 257
27—Maintenance of Way Work Equipment 273

Bulletin 590, January 1965 (Reports of Committees)
15—Iron and Steel Structures 291
7—Wood Bridges and Trestles 299
8—Masonry 305
24—Cooperative Relations with Universities 325
18—Electricity 339

Bulletin 591, February 1965 (Reports of Committees)
4—Rail 445
5—Track 495
31—Continuous Welded Rail 507
1—Roadway and Ballast 521

Bulletin 593, June–July 1965
Report of the 64th Annual Convention, March 23–25, 1965 587
Tie Renewals and Costs Per Mile of Maintained Track 780
Memoir, John Edwin Armstrong 781
Report of Executive Secretary 785
Report of Treasurer 805
Constitution 807
Index of Proceedings, Vol. 66, 1965 819

American Railway Engineering Association—Bulletin

Bulletin 587
Proceedings Vol. 66*

September–October 1964

CONTENTS

Man-Machine Communication in Civil Engineering ----- 1
Construction of the Great Slave Lake Railway --------- 31
An Industrial Engineering Study of a Freight Car Repair Facility -- 49
Epoxy Resin Coatings on Steel and Concrete ---------- 59
Corrosion of Deck Plates After Five Years of Exposure -- 73

---

* The contents of this Bulletin and subsequent Bulletins of the Association to and including Bulletin 593, June–July 1965 (except Bulletin 592, March 1965), will constitute the Annual Proceedings of the Association. Accordingly, this issue of the Bulletin should be carefully preserved for inclusion in the Proceedings book-type binder which will be made available on request from the secretary's office, following publication of the June–July issue.

Copyright 1964, by American Railway Engineering Association

BOARD OF DIRECTION

1964–1965

President

T. F. Burris, Special Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

Vice Presidents

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.

J. M. Trissal, Vice President, Illinois Central Railroad; Vice President—Development, Illinois Central Industries, Chicago, Ill. 60605

Past Presidents

C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania Railroad, Philadelphia, Pa. 19104

L. A. Loggins, Chief Engineer, Southern Pacific Company, Texas and Louisiana Lines, Houston, Tex. 77001

Directors

W. L. Young, Chief Engineer, Norfolk & Western Railway, Roanoke, Va.

T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va. 23213

C. E. Defendorf, Chief Engineer, New York Central System, New York, N. Y. 10017

John Ayer, Jr., Vice President—Operations, Denver & Rio Grande Western Railroad, Denver, Colo. 80217

A. L. Sams, Chief Engineer, Illinois Central Railroad, Chicago, Ill. 60605

D. C. Hastings, Assistant Vice President—Operations, Atlantic Coast Line Railroad, Jacksonville, Fla. 32202

B. B. Lewis, Professor of Railway Engineering, Purdue University, Lafayette, Ind.

H. M. Williamson, Chief Engineer System, Southern Pacific Company, San Francisco, Calif. 94105

H. E. Wilson, Assistant Chief Engineer—System, Atchison, Topeka & Santa Fe Railway, Chicago, Ill. 60604

J. S. Parsons, Chief Engineer, Erie–Lackawanna Railroad, Cleveland, Ohio. 44115

S. H. Poore, Office Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

F. N. Beighley, Roadway Engineer, St. Louis–San Francisco Railway, Springfield, Mo. 65801

Treasurer

A. B. Hillman, Retired Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago.

Executive Secretary

N. D. Howard, 59 East Van Buren Street, Chicago, Ill. 60605

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Street, Chicago, Ill. 60605

Secretary Emeritus

Walter S. Lacher, 407 East Fuller Road, Hinsdale, Ill.

Published by the American Railway Engineering Association, Monthly, January, February, March, November and December; Bi-Monthly, June-July, and September-October, at 2211 Fordem Avenue, Madison, Wis.; Editorial and Executive Offices,
59 Van Buren Street, Chicago 5, Ill.
Second class postage paid at Madison, Wis.
Accepted for mailing at special rate of postage for in Section 1103, Act of October 3, 1917, authorized on June 29, 1918.
Subscription $10 per annum.

Advance Report of Committee 16—Economics of Railway Location and Operation

Report on Assignment 4

Potential Applications of Electronic Computers to Railway Engineering and Maintenance Problems in Research, Design, Inventory, Etc.

Collaborating with Committees 11 and 30 and Informally with the Railway Systems and Management Association

L. P. Diamond (chairman, subcommittee), G. B. Dutton, Jr., S. B. Gill, C. A. James, T. J. Lamphier, R. J. Lane, A. S. Lang, M. B. Miller, V. J. Roggeveen, George Rugge, J. J. Stark, Jr., F. Wascoe.

Man-Machine Communication in Civil Engineering*

By C. L. MILLER

Head, Department of Civil Engineering, Massachusetts Institute of Technology

ABSTRACT

The performance of engineering with the aid of a computer is basically a problem in man-machine communications. Traditional methods for communicating with the computer are quite primitive and poorly matched with the capabilities of the engineer and the characteristics of engineering problems. The conventional library-of-programs approach to the use of a computer is incompatible with most engineering situations. Such an approach forces artificial constraints on the formulation of the problem and seriously impairs the role of the engineer. The net result is that, in most cases, the full potential usefulness of the computer is far from realized, and, in some cases, the computer is badly misused.

Recent developments in computer hardware and software technology point the way to very major changes in the way in which engineers communicate with computers. The most significant advances in hardware of importance to the engineer-user relate to input/output capabilities which allow for efficient and effective interaction between the man and the machine in an on-line mode. The most significant advances in software relate to problem-oriented programming languages for describing engineering situations to the computer. The combination of such hardware and software capabilities on a time-shared computer represents a totally new level of man-machine communications ability which will materially change the role of the computer in engineering. Examples of current development in this area, and their potential impact on engineering practice and engineering education, will be discussed.

Introduction

The civil engineering profession can take pride in the early and extensive adoption of electronic computers in civil engineering practice. Computers are probably used more extensively in civil engineering today than in any other branch of engineering for civilian applications. However, the computer field is changing in a number of very significant ways which tend to make obsolete our past and present methods of computer usage. It is important that we not only understand these trends, but also lead in their exploitation.

---

* Keynote address for the Third National Conference on Electronic Computation, Structures Division, American Society of Civil Engineers, Boulder, Colo., June 19–21, 1963.

Although we recognize that the first generation of machines is now obsolete, we are in danger of failing to recognize that many of the first generation of methods, concepts, approaches, attitudes, and operational modes are also obsolete. Most organizations are now using second-generation *machines,* but they are staffed by first-generation *people.* These people have not necessarily adapted themselves to many important changes in computer usage.

Computer people, like all other human beings, tend to resist change. After five to ten difficult years of learning how to use computers in a well defined and smoothly operating way, there is a natural resistance to change which would tend to make all their hard work obsolete and to discount their hard-won experience. Herein is the great danger and the great challenge—to insure that our people do not rest on obsolete ideas and methods. This applies not only to technical specialists, but also to management leadership. One of the great tragedies of today is the numerous senior and key people managing civil engineering organizations whose attitudes toward the criteria and evaluation of computer usage were shaped five years ago, based on premises which are no longer valid.

In this paper, we shall examine our past and present methods, discuss their shortcomings, and review some of the current developments which must shape our future thinking and methods. Although most of the examples will be drawn from current activities at M. I. T. because they are best known to the writer, similar work is underway in many other places which will influence the future of computers in civil engineering. Although much of what will be said is applicable to engineering in general, the remarks and material are specifically directed to the civil engineering profession.

Classical Computer Methods

During the past decade, a well established pattern of computer usage has been built on the concepts of the *program* and the *program library.* Hundreds of computer centers in civil engineering organizations were established and are being operated on the basis of these concepts. A generation of computer users, computer staff people, and organization managers have developed mental attitudes and operational mechanisms based on these concepts. The concepts of a program and program library are an outgrowth of traditional methods of programming, which called for skilled specialists (programmers), great investment in time and money, and well defined program situations.

During the same period numerous doctrines regarding problem requirements for computer usage were established. The requirements repeated most often have been that to justify use of a computer on a problem, the problem must have one of the following characteristics:

(a) The problem must be very *repetitive,* occurring often enough in the same form to allow use of the program many times.

(b) The problem must be very *complex,* involving computational effort which would be prohibitive by manual methods.

Computer libraries are full of the first type; journals and magazines are increasingly full of papers based on the second type.

The development of a typical classical program involves such well known steps as problem definition, mathematical and logical analysis, flow charting, programming, coding, debugging, testing, and documentation. These steps often require months of time and thousands of dollars. The development of a useful program, being such a major task, rather completely controlled how and to what extent computers could be effectively used in engineering. As program libraries develop, the question of *computer usage is usually decided on the basis of whether or not a program is available in the library which matches the problem situation.*

Limitations of Classical Methods

The characteristics of engineers and engineering problems are poorly matched with the characteristics of classical computer methods. The classical program, if it is to be used more than once, implies that the same situation will repeat itself and that the same method of solution can be used. A few routine computational problems fall in this category. However, most real engineering situations, particularly those of interest to the true professional engineer, usually have unique characteristics and conditions. The pressure to "use computers" under such circumstances yields the most valid criticism of classical computer usage—the attempt to *force engineering problems to conform with the input requirements* of an available library program in order to make use of the computer. This is sufficient reason alone to demand a major change in how we communicate with computers.

Classical programs have attempted to cope with the extreme variation in engineering problems in two ways. Many programs provide options or exist in different versions, each adapted to a somewhat different set of conditions. Such attempts have been of limited success due to the almost limitless number of different combinations of what is known and what is unknown in most significant situations. An examination of the typical program library reveals that most organizations are attempting to avoid the variation problem by *breaking engineering problems up into small pieces,* each of a routine computation nature. Each piece constitutes an individual program which hopefully will find repetitive use, but more often merely adds to the size of the library (a common measure of the success and degree of computer activity of an organization). This results in *hundreds of individual programs,* independently developed and rarely coordinated. The problem of how one copes with a moderately complex engineering situation with all of these pieces of a jigsaw puzzle is left to the engineer-user, who often finds that the pieces do not fit together very well.

There is evidence that expensive library programs may become *real obstacles to technical and professional progress.* Classical programs are based largely on traditional procedures, specifications, design criteria, theory, and knowledge. By their very nature, they often represent very sizeable financial investments on the part of the originating organization, and are costly, if not impossible, to modify to bring them up to date. From a business investment standpoint, there will be considerable reluctance to junk such programs. The profession is not yet fully conditioned to the idea of obsolete programs, but we cannot afford to let such programs and their owners stand in the way of professional progress.

The degree of rigidity inherent in most classical programs is clear when one notes the current status of the *input form.* Indeed, one practical way to define classical programs is to state that such programs require input forms. The routine filling out of standard forms for rigid computer programs is completely distasteful and uninteresting to the engineer. Forms have their place, but it is extremely unfortunate that they have become the sole means of communication between engineers and computers in many instances. As a result, many engineers have developed mental attitudes that computers are only applicable to routine non-creative applications.

Under the conditions suggested above, it is quite understandable that the computer usage situation leaves much to be desired. Despite the tremendous publicity given to computers in recent years, and the impression that all is well, it should be acknowledged that the real results have often fallen considerably short of many expectations. Few organizations dare to admit this publicly, since all of their competitors claim success. The great national race as to who is ahead in the computer game has at least been amusing in many respects. A few people will admit privately that the only reason they have a computer is that their clients expect it, and it makes them look progressive. In particular, people who had expected to "make money" with computers in engineering often have been disillusioned.

Fortunately, the past and present situation is no indication of what the future holds. Although it will be necessary to write off the past decade as a very costly education, if we are willing to take a fresh outlook on the whole area of computer usage, the future holds great promise for exceeding our fondest expectations.

The Engineer and the Engineering Process

The most important by-product of attempts to use computers is the extent to which such activity is now forcing us to critically examine the true *role and function of the engineer and the nature of the engineering process.* Whereas in the past we have tended to let the requiremnts of the computer dictate how they were used, in the future we shall be in a position to let the characteristics of the engineer and engineering dictate the requirements of the computer system. This implies that we understand the role of the engineer and the nature of the engineering process. A complete discussion of the writer's views on this subject is beyond the scope of this paper. However, a few remarks will be made.

The engineering process may be thought of as a *decision-making process.* The engineer is called upon to make a series of complex, interrelated decisions. For example, the engineer must make decisions as to the feasibility of a project; decisions or choices between alternative locations; design decisions at all levels, varying from overall layout to the dimensions of the minutest detail; decisions or choices between alternative materials; decisions of a compromise nature such as conflicts between performance and cost; decisions relative to safety and reliability; and decisions relative to predicting future change. These are but a few of the more obvious areas of decision making which confront the engineer. Although many kinds of professional people (lawyers, bankers, politicians, architects, planners, etc.) play a role in the decision making, the engineer is solely responsible for bringing an *understanding of the physical world* to bear; hence, the fundamental importance of scientific knowledge in the education of the engineer.

In making the decisions for which he is responsible, in addition to calling upon his understanding of scientific fundamentals, the engineer makes use of *extensive information* pertinent to the particular problem at hand. Such information is of three basic types:

(a) Information relative to the *requirements* to be met by the solution. For example, performance requirements, client's specifications, etc.

(b) Information relative to the *physical environment* of the solution. For example, topography, land use, geology, hydrology, etc.

(c) Information relative to the *solution resources* and *constraints.* For example, physical and economic characteristics of potentially available materials and capabilities for achieving the solution, codes, social and political constraints, etc.

One of the important characteristics of engineering decision making is the degree to which we must work with *inaccurate and incomplete information.* In general, we must work with a high degree of uncertainty in data which represent relatively small samples. Even if the variables can be precisely measured, the cost of complete information is prohibitive. Many critical variables defy precise measurement at any cost. Of particular significance in engineering are the many important variables and factors which are non-quantifiable. Yet decisions must be made, usually under pressure of time. Despite such obstacles, the engineer is responsible for producing the "*optimum design*" or "*best solution*"—the one which is the most economical, politically and socially acceptable, and the one which also works! In so doing, he must be *creative* and utilize *imagination, judgement, intuition, and experience,* as well as a vast array of tools, techniques, and assistants. If we *define the engineer as the man who makes the significant decisions* in an engineering organization, remarkably few engineers exist in the average organization. Probably less than 5 percent of the typical staff meet this qualifying requirement, the balance of the staff being information handlers and information processors.

An engineering organization may be thought of as a large information system. Large amounts of raw information are fed in by surveyors of various types. The information is reduced, processed, stored, and later combined with other kinds of information which are stored in various kinds of files maintained by the organization. Significant decisions made by the true engineers set in motion extensive information-processing activities by a vast array of information handlers. Draftsmen and technicians of various kinds produce information displays (plans, drawings, charts, etc.) which communicate the decisions to others. Low-level decisions, made in accordance with well defined procedures and rules, are made by a huge number of people bearing the title of engineer or designer, who are in reality technicians, even though most of them have a college degree. (These are the people who do what classical computer programs can do now.)

The above concept implies that a rather sharp distinction be made between *engineering as decision making,* on the part of a relatively few engineers, and *information handling and plan production,* as the principal occupation of a vast number of technicians serving the engineer.

Ultimate Role of the Computer

If the concepts of the engineer and the engineering process previously proposed are at all valid, it follows that the *proper role of the computer is to assist the engineer in making decisions* involving choices between alternatives and large amounts of information. The computer is ideally suited for this role because it is basically a *logical device and information processor,* not a mere calculating machine. Much of the information handling and processing activity now handled within engineering organizations by the vast army of technicians, can be potentially accomplished very effectively and efficiently by computers. This includes not only computation, but also secondary decision making (the kind made by technicians), drafting and data display, searches for alternate designs, storage of the complete files of previous information, exhaustive checking and testing of solutions, communications, comparisons with experience (previous solutions and their performance results), innovation suggestions, etc.

Why aren't computers serving such a role in engineering organizations today? Primarily, because it is still much *easier to give instructions to a human being than it is to give instructions to a computer.* Essentially, man-man communication is much easier and cheaper than man-machine, and machine-man communication. Engineers and technicians communicate with each other via meaningful technical *words* and graphical *symbols.* A single technical word between humans may be equivalent to thousands of machine instructions. A few seconds of explanation to a draftsman may be the equivalent of hours of explanation to a computer. Secondly, because the response time of a human information system still tends to be much faster than the total response time of a machine information system. Essentially, in terms of total elapsed time, humans are often able to return results to the decision maker in less time than computer. Even if the computer is able to accomplish in 10 sec a job which would require 1 hr of a human, the latter may be preferable if the computer result is not delivered for 24 hr.

From the preceding, it may be concluded that computers will not be able to serve their full potential role unless:

(a) The level of communication between the engineer and the machine is at least as efficient as communication between engineers.

(b) The response time between the engineer and the machine is grossly reduced.

The first is a *communications (language) problem,* and the second is a *machine accessibility problem* (also a form of communications problem). In both cases, the solution must be achieved in economic terms which make it attractive to use the machine.

Programming Languages and Systems

For purposes of this discussion, a programming language will be defined as the language for expressing instructions or commands to a computer to perform operations. A programming system will be defined as the software procedures required to implement a given language on a given machine. The objective of programming languages is to provide a higher level of communications than the primitive coded instructions of machine language. Since all instructions must ultimately be reduced to machine language before they can be executed, the function of a programming system is to translate the external programming language into internal machine language. This translation is, of course, accomplished by a program and on the computer.

Symbolic assembly languages represent the first step above basic machine language. Such languages have the advantage that essentially the full power and flexibility of machine language is preserved. With the addition of extensive macro-instructions, such languages have become increasingly efficient, but are still very time consuming. Routines written in a symbolic assembly language have the disadvantage that they are usually not interchangeable between different types of machines. However, such languages are still widely used to develop classical programs.

In recent years, *algebraic compiler languages* have become very popular for programming engineering problems. Languages such as FORTRAN represents a very major step toward higher level communications. In addition to permitting instructions in meaningful mathematical and logical terms, routines written in such a language are increasingly machine independent. The widespread use of FORTRAN has resulted in the availability of programming systems for many different types of machines. At the present time, algebraic compiler languages may be considered to be the standard or most common programming language for developing classical programs.

Although symbolic assembly and algebraic compiler languages are suitable for developing classical programs, they are completely inadequate for the level of communication necessary for the computer to achieve its ultimate role in engineering practice. The first significant step in this direction is to raise the level of communication to the point where instructions to the computer are in essentially the same terminology as engineers use in communicating with each other. This is the objective of problem-oriented languages—

to use engineering terms to express instructions or commands to the computer. Due to the future importance of *problem-oriented languages,* this subject will be discussed in more detail in the following section.

Problem-Oriented Languages and Systems

In addition to permitting the engineer to instruct the computer in the technical terminology of the problem area, the ideal problem-oriented language and associated programming system should meet a number of other important specifications, such as the following:

(a) Each engineering problem or situation should be considered to be *unique*. No two problems should be constrained in any way to be exactly alike. Each use of the machine by the engineer is considered to be for the purpose of coping with a completely *original* problem, involving creative thinking on the part of the engineer, and complete freedom of use of human imagination, judgement, intuition, and experience. The system must accept the description of the problem as conceived by the engineer, and be prepared to respond to his wishes. This means that the order of instructions is under the complete control of the engineer.

(b) Assuming that the engineer is working with the computer for the purpose of obtaining assistance in making decisions, the response of the computer in terms of results produced by a given command should be designed primarily for decision making. Special attention must be given to ease of change or modification of the "design." In general, the machine will be most useful, not in reporting the answer, but in reporting meaningful measures of the *consequences* of a decision on the part of the engineer. In so doing, the internal processing may involve considerable logical decision making related to searches, comparisons, checks, optimizations, combinations, and specifications, as well as computations. The response should provide the engineer with a basis for evaluating whether or not his decision has been a good one or a poor one—in *his* judgement.

(c) No constraint should be placed on the size of the problem being considered. This does not mean that the machine must be infinitely large. Most constraints on problem size, even in classical programs, are more often the result of unimaginative programming than physical machine size. Only that information pertinent to the decision of current concern to the engineer need be in internal memory at one time, all other files merely being automatically accessible. In essence, it should *appear* to the engineer that his problem is handled continuously and can be indefinitely long.

Just as the role of the computer is causing us to re-examine the role of the engineer and the engineering process, the development of problem-oriented languages is causing us to re-examine the various classes of engineering problems. It is no longer sufficient to merely identify repetitive situations for purposes of writing a classical program. Considerable understanding of the fundamental building blocks of problem solving must be gained. What terms or commands should be in the language? The more powerful a command, the more inflexible it tends to be. How in fact do we describe problems and their solutions to each other? What are the factors which influence engineering decisions? How do we systematically cope with vagueness and ambiguity in communications? These and a host of complex questions are raised for the first time. For these reasons, computer methods research is concerned with the very heart of engineering practice.

Problem-oriented programming systems are not developed as one huge but flexible program. Rather, they may be thought of as a collection of subroutines which can be automatically linked or called as needed to accomplish the operations associated with a particular user command. Hence, each problem-oriented command or statement sets up a series of switches which internally link a set of subroutines which in turn operate on the information pertinent to the command. The commands share common subroutines, and the subroutines may share common data tables which provide carryover between commands.

The subroutines used internally may usually be written in an algebraic compiler language like FORTRAN, and compiled as subprograms. This is important because it means that the majority of the programming effort associated with the development of a problem-oriented system may often be accomplished in an efficient and machine independent system. The only routines which may of necessity require machine or symbolic assembly language coding are usually those associated with the control or monitor program and the statement scanning and coding routines.

It is extremely important that problem-oriented systems be designed for *ease of modification and change*. The subroutine concept is of fundamental importance in allowing new commands, better theories, new specifications, and new algorithms to be added to the system at will. Such a system should always incorporate the latest developments in engineering and never be allowed to become frozen.

COGO and STRESS—Prototype Examples

The COGO language and associated programming system represented one of the first major breaks with classical computer methods in the field of civil engineering. Development of the system was initiated in Puerto Rico and at M. I. T. by the writer in 1960, and was first placed in operational use in the Puerto Rico Department of Public Works in 1961. Operational versions are now being made available by IBM, and similar systems (under other names) have been and are being developed by other manufacturers. The system has been applied to many thousands of problems in engineering practice during the past two years, and the practical advantage of such an approach to computer usage has been clearly established.

As a problem-oriented language, COGO (for COordinate GeOmetry) is concerned with geometric problems in civil engineering. All such problems in surveying, highway design, layout, etc., involve a set of common terms and operations. These include such terms as point, line, area, station, coordinate, locate, azimuth, intersect, inverse, offset, etc. Such terms are the basis for a set of commands which can be used to express the solution to an indefinite number of unique problems. Associated with each command is a list of data which is operated on by the computer to produce the results of interest to the engineer. A separate and unique program is written for each situation as it occurs. Hence, instead of a library of fixed programs, a single system is applicable to an unlimited number of different geometric problems.

Although COGO and related systems will continue to be of practical value in engineering operations for geometric problems, the system is also of some historical interest because of the extent to which it demonstrated the usefulness and impact of a problem-oriented approach. COGO itself is undergoing a continuous and rapid evolution as experience shows the way for even more powerful and sophisticated versions. Of even more importance, it has served to stimulate interest in a wide variety of systems applicable to other types of problems in civil engineering.

One of the most recent major advances in the area of problem-oriented systems of interest to civil engineers is the development of the STRESS system. STRESS (for STRuctural Engineering System Solver) has been developed in the Department of Civil

Engineering at M. I. T. during the past year by a research team under the leadership of Dr. Steven J. Fenves (visiting associate professor at M. I. T. on leave from the University of Illinois), and Dr. Robert Logcher and Dr. Samuel Mauch of the M. I. T. faculty. A system which will handle linear, elastic framed structures is now operational and is in use. A major expansion of the research team this summer, and a continuation of the work jointly at M. I. T. and Illinois during the next year is planned to extend the scope of the system and its application to engineering practice and education.

The STRESS language includes a series of commands which allow the engineer to describe the topology of a structure, the loads acting on it, the method of analysis, member properties, and the results which are desired. All of the advantages and objectives of a problem-oriented approach previously mentioned, are inherent in the system. Each analysis and design situation is considered to be an original problem.

COGO and STRESS, although subject to higher development, exist in fully operational forms. Work on a number of other systems for other classes of problems is being initiated at M. I. T. These include languages and systems for problems in transportation, traffic, highways, critical-path scheduling, soils, and on-line research experiments.

Graphical Communication with Computers

The civil engineering profession has shown considerable interest in the automatic plotting of computer output. Various kinds of off-line point and line plotters have been tried with varying degrees of success. The disadvantages of such plotters are that they tend to be rather costly and inflexible. The economics of their use has not always been very favorable and the quality of the drafting has not always been acceptable. The emphasis on producing final plans and drawings directly from computer output, although a worthwhile objective, has detracted from other aspects of the graphical problem.

A distinction should be made between plan production, display for decision-making, and graphical input. The purpose of the final plan or drawing is to store information and the results of decisions, and to transmit this information between interested parties. The purpose of the display is to assist the engineer in his decision-making role by showing the results of computer processing of information in a meaningful and efficient form for human evaluation. The purpose of graphical input is to permit the engineer to express his ideas and problems in the form of sketches in the same manner that he communicates with other engineers and with himself. Each of these has certain special and unique requirements which must be recognized.

Since the uses and limitations of off-line devices for plotting computer output are relatively well known, we shall devote our attention to on-line plotting, display, and graphical input devices. For purposes of plotting information for immediate evaluation, a CALCOMP plotter is being used on-line with the IBM 1620 in the Department of Civil Engineering at M. I. T. with considerable success. One of the major attractions of such a plotter is that it is quite inexpensive and very easy to use. Plot commands have been added to the FORTRAN system and are being extended to the problem-oriented systems. Such a plotter is a minimum requirement for on-line work in many civil engineering problem areas.

Scopes have been used extensively as display devices and with the addition of a light pen, can be used quite effectively for graphical input. Scope and light-pen techniques for graphical input/output is an area of major attention by a number of groups at M. I. T. The Sketchpad system, developed by Dr. I. E. Sutherland at the M. I. T. Lincoln Laboratory, using the TX–2 computer, represents an exceptionally important advance in this area. In addition to the development of a set of very sophisticated programs, Sketchpad has introduced a number of original concepts and techniques which will play very significant roles in the future of graphical communication with computers. Sketchpad also has demonstrated the feasibility of a host of practical applications of computers which are bound to influence civil engineering considerably. It clearly points the way to the feasibility of the computer achieving its ultimate role in civil engineering as previously described.

Machine Access Considerations

Problem-oriented programming systems make the computer very accessible to the engineer in terms of language. However, since each engineer does not have his own computer, traditional modes of operation still make the machine quite inaccessible in terms of *physical access.* Machine accessibility is of basic importance in the use of computers in engineering. In order to increase availability, most civil engineering organizations have installed their own computer. The size of machine has been dictated by the simple practical factor of the amount of money the organization could afford to pay for a computer. Even with a computer within an organization, the turn-around time usually varies from two hours to two days. This is sufficient time to discourage use of the machine on anything but "large" problems. Even more serious, such a mode of operation eliminates any possibility of interaction between man and machine for on-line thinking and decision-making.

For the computer to achieve its ultimate role, it must be made much more accessible to the engineer. Ideally, each engineer should have direct access to a computer whenever he needs it, and he should be allowed to work on-line with the machine for prolonged periods. This can be accomplished in two basic ways:

(a) By grossly decreasing the ratio of engineers to computers. This means fewer engineers, and/or more computers. Defining the engineer in the way in which we do, plus the greater capacity of each engineer resulting from computer amplification of his capabilities, implies that we shall, in fact, need fewer engineers. At least, we shall not need the large number of people now called engineers who are engaged in manual information processing. The number of computers in existence is clearly increasing at a fast rate. At the same time, rapid advances in computer technology and production economics suggest that unit costs of computer operations will continue to decrease at a rapid rate. If this trend continues, we may, in fact, be able to afford a very low ratio of engineers to computers.

(b) By making a single computer, shared by a number of engineers, appear to the individual user as though he is the only user. This is the objective of time-sharing systems of computer operation. Whereas solution (a) above may eventually develop and may be appropriate for many classes of use, the time-sharing approach is of more immediate concern and is the only way the largest machine existing at any one time can be made available simultaneously to multiple users.

Time-Sharing of Computers

Time-sharing involves equipping a single computer with a large number of separate consoles (input/output and control devices) which allow a number of individual users to work at the machine simultaneously. This machine is shared by the individual users, not in the sense of each being given a proportional part of the machine, but in the sense that each has direct access to the computer. The individual consoles are multiplexed, a master control system switching between consoles at high speed, serving each console briefly. During the time a console is being served, essentially the full machine is available to that user. Each user is assigned a set of files in a large secondary memory (such as a disc file) for the storage of his programs when he and his console are not being served.

Due to the extremely high speed of modern high-speed computers, the frequency of service will be such that it will appear to him that he has *continuous use* of the machine. During a 2-hr sitting at the console, he may require the full attention of the central processor for a total of perhaps only 3 min (the accumulation of a number of fractional seconds of attention). The balance of the time would be consumed in input/output, thinking, discussions with a fellow engineer, evaluation of results, etc., which do not require the services of the central processor. For these conditions, the machine could also have been serving 39 other users during the same 2-hr period, each consuming an average total of 3 min. Accordingly, it should be clear that only the *time* of the machine is being shared, not its speed or capacity.

One of the most attractive features of the time-sharing approach is that the individual consoles can be quite *remote* from the computer. Since the connecting link can be a telephone line, the consoles can be quite remote from the computer. This is particularly significant in civil engineering since we are concerned with a very large number of modest size organizations. Hence, time-sharing and telephone linkage is very significant because it suggests that *every organization, no matter how small, could afford to give its engineers access to a computer.*

The time-sharing approach to computer usage has been compared to electric power and telephone communications systems. Large central power plants and telephone exchanges serve a large number of individual customers or users, each having service on demand in an easily accessible form. Each pays only for his share of the central plant, based on the time and capacity used.

M.I.T. Time-Sharing System

An experimental time-sharing system has been developed at M. I. T. by the staff of the Computation Center. The system in current operational use is based on an IBM 7090 (to be replaced by a 7094 this summer) with a 64K memory, 15 magnetic tape drives, and an IBM 1301–2 disc file with a storage capacity of 9 million words. An IBM 7750 Teleprocessing unit is used to link individual consoles with the computer. The planning of the system and the development of the executive and supervisor programs to handle switching, scheduling, storage allocation, console control, and related software is under the supervision of Dr. F. J. Corbato, associate director of the Center. The system features a background system which allows normal batch program runs to be handled as well as the on-line console work. With this arrangement, the computer is never idle, even if none of the experimental consoles are in use.

Considerable attention is being directed to the matter of the ideal console for man-machine interaction. The problems are not so much technical as they are a matter of economics. Elaborate consoles are very costly, yet the objective is to be able to afford a very large number of consoles. With typically over 500 active computer users, one needs a great number of points of access. As an interim measure, approximately 20 typewriters are being used initially in the M. I. T. system. Standard Teletype keyboard-printers are being used in most cases. Although such a simple input/output device represents the minimum requirement, it will allow considerable practical experience to be gained while inexpensive but more elaborate consoles are being developed. Console development activity is underway in a number of departments at M. I. T., including Electrical Engineering, Mechanical Engineering, Civil Engineering, and the Electronic Systems Laboratory. Applied programming work related to time-sharing is also under way in the same departments, plus others.

To expedite the progress in developing time-sharing, plans are well advanced to implement a very large scale national project at M. I. T., headed by Dr. Robert Fano, under the sponsorship of the Advanced Research Projects Agency of the Department of Defense. In addition to the various M. I. T. groups, individuals and groups from a number of other organizations will participate. A duplicate of the equipment configuration in the Computation Center will be installed to be used exclusively for time-sharing experiments.

Time-Sharing in Civil Engineering at M.I.T.

In addition to having one of the previously mentioned Teletype units installed and in operation in the Department of Civil Engineering, work is underway to use the Department's IBM 1620 computer system as a remote console in the M. I. T. time-sharing system. The objective is to make use of the 1620 as an input/output device having many of the features of a more elaborate remote console. In addition to making use of the standard console features and input/output devices of the 1620, the machine has been equipped with a general-purpose input/output control to permit attachment of a large number of additional special purpose devices. For example, a graphical plotter has been installed as an additional output device. Through a data exchange system, facility to accept data from a number of research laboratory experiments will be provided. A Dataphone is being used as the telecommunications link with the 7750 in the Computation Center. For similar experimentation, particularly for development of CRT and light-pen usage for input/output, the PDP–1 in the Department of Electrical Engineering is being linked to the Computation Center for use as a remote console.

Time-sharing versions of the COGO and STRESS programming systems are already operational. Previously developed engineering systems such as the Digital Terrain Model System are also being adapted to time-sharing. During the coming year, the Department will have an opportunity to obtain considerable experience in the development and use of time-sharing methods for civil engineering teaching, research, and practice. Special attention is being given to new approaches to the teaching of engineering and design which time-shared computer methods and problem-oriented languages make feasible. Many aspects of engineering decision-making and engineering design are matters of experience. By making it practical for the student to be able to cope with and respond to a very large number of engineering situations in a short time, the equivalence of many years of experience might be possible. Whereas, traditional subjects have dealt almost entirely with analysis, since analysis can now be made almost completely automatic and of essentially zero time, the student will be able to concentrate on engineering decision-making and design.

Civil Engineering Education and Practice

The trends and developments which have been discussed can have considerable impact on how we teach and practice civil engineering. Perhaps one of the greatest goods which such computer developments may bring about may be the bringing together of civil engineering education and practice. There has been considerable discussion of late of the extent to which civil engineering education and practice have drifted far apart. The gradual elimination of many of the traditional subjects from the curriculum, the emphasis on science in research and teaching, and the interest in such new fields as computers, have been interpreted by many professional practitioners as a lack of interest in and understanding of the civil engineering profession on the part of the educators. Criticism of what is going on in the civil engineering schools has been increasingly vocal, reaching an attitude of mistrust and questioning of motives. At the same time, many educators have been critical of their critics on the assumption that they were holding out for the traditional for purely emotional reasons, short-term business concern, and fear of the new and unknown.

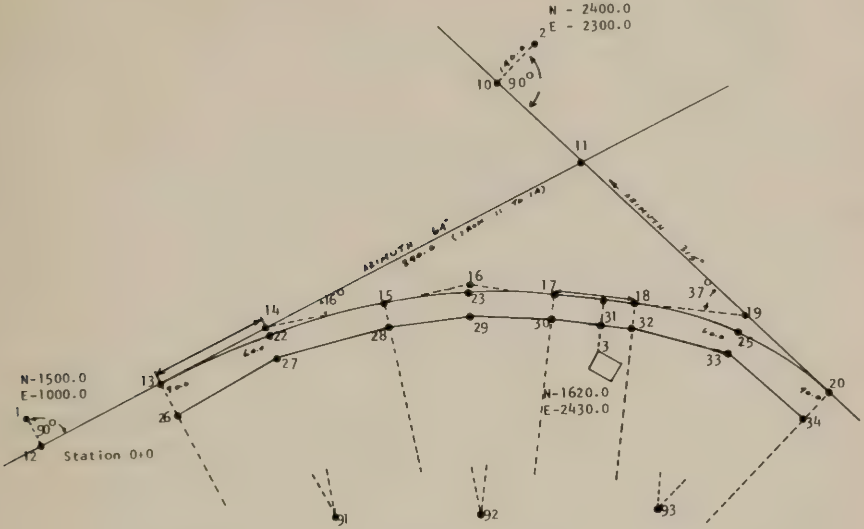
The kinds of computer usage developments discussed herein are intimately associated with civil engineering practice, indeed, with the future of the profession. Such research is by no means a retreat from the realities, but requires a deep understanding of engineers and the engineering process in real life. It is good that such research has been originated in the engineering schools because the schools should be the source of innovation and change. But for obvious reasons, such research and its implementation should be conducted in close partnership with professional practitioners. Together, we can achieve a future for our profession which will make it an exceptionally exciting area of activity of great reward and satisfaction to all of us.

REFERENCES

1. Alexander, C. and M. Manheim, *The Design of Highway Interchanges; An Example of a General Method for Analyzing Engineering Design Problems,* Department of Civil Engineering, M. I. T., R62–1, March 1962.
2. Coons, S. A., *An Outline of the Requirements for a Computer-Aided Design System,* Proceedings of the Spring Joint Computer Conference, Detroit, 1963.
3. Corbato, F. J., M. M. Daggett, and R. C. Daley, *An Experimental Time-Sharing System,* Proceedings of the Spring Joint Computer Conference (National Press, Palo Alto, Calif., 1962).
4. Fenves, S. J., *STRESS (Structural Engineering System Solver), A Computer Programming System for Structural Engineering Problems,* Department of Civil Engineering, M. I. T., T63–2, May 1963.
5. Greenberger, M. (Ed.), *Management and the Computer of the Future,* M. I. T. Press and Wiley, 1962.
6. Greenberger, M. and H. W. Johnson, *Automation, Management, and the Future,* Technology Review, M. I. T., May 1963.
7. Johnson, T. E., *Sketchpad III: A Computer Program for Drawing in Three Dimensions,* Proceedings of the Spring Joint Computer Conference, Detroit, 1963.
8. Licklider, J. C. R. and W. E. Clark, *On-Line, Man-Computer Communications,* Proceedings of the Spring Joint Computer Conference, Detroit, 1963.
9. Manheim, M. L., *Model-Building and Decision-Making,* Department of Civil Engineering, M. I. T., R62–10, May 1962.
10. Miller, C. L., *COGO—A Computer Programming System for Civil Engineering Problems,* Department of Civil Engineering, M. I. T., August 1961.
11. Roberts, P. O. and J. H. Suhbier, *Highway Location Analysis, An Example Problem,* Department of Civil Engineering, M. I. T., R62–1, March 1962.
12. Roos, D., *COGO–90, A Civil Engineering Problem-Oriented Language,* S. M. Thesis, Department of Civil Engineering, M. I. T., January 1963.
13. Ross, D. T. and J. E. Rodriquez, *Theoretical Foundations for the Computer-Aided Design System,* Proceedings of the Spring Joint Computer Conference, Detroit, 1963.
14. Stotz, R., *Man-Machine Console Facilities for Computer-Aided Design,* Proceedings of the Spring Joint Computer Conference, Detroit, 1963.
15. Sutherland, I. E., *Sketchpad: A Man-Machine Graphical Communications System,* Proceedings of the Spring Joint Computer Conference, Detroit, 1963.
16. ———, *COGO I Program Documentation,* IBM Corporation, May 1963.
17. ———, *Educational and Research Activities in Civil Engineering at M. I. T.,* Department of Civil Engineering, M. I. T., January 1963.

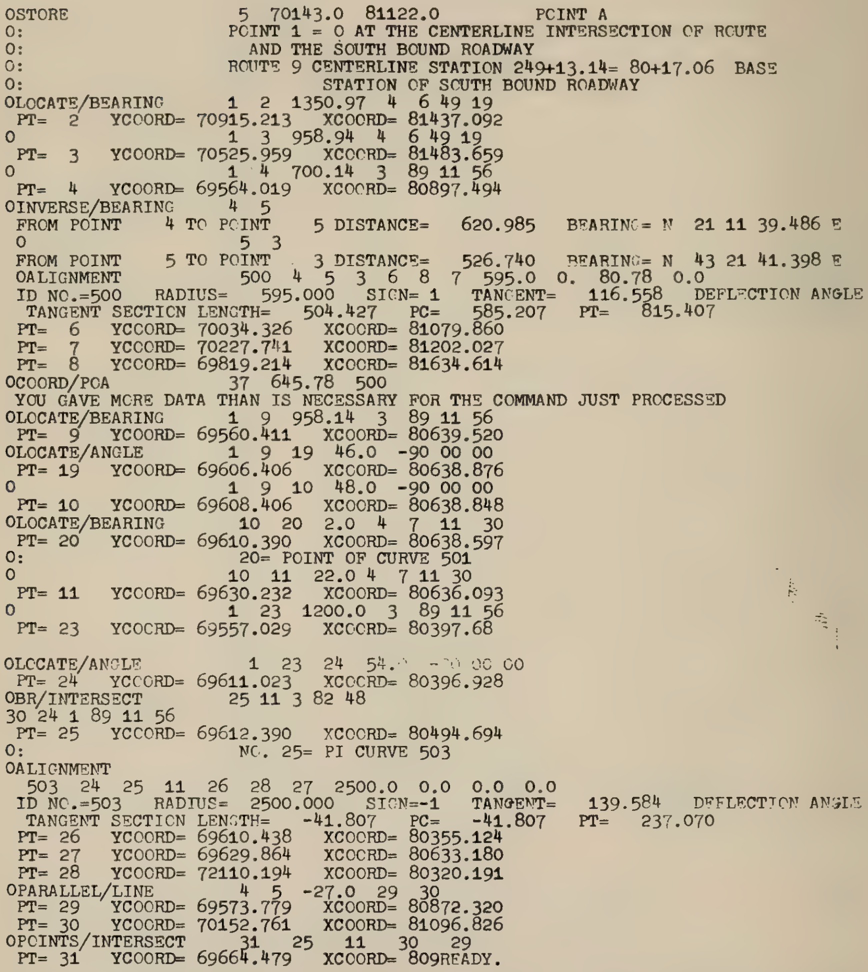
Typical Instructions or Statements	Meaning of Instruction or Statement
Machine Language (1620)	
460793201200	Branch to loc. 07932 if the equal-zero indicator is on
1207855000$\bar{1}$0	Add 10 to the field at loc. 07855
1407855$\bar{1}$9619	Compare field at 07855 with 19619
470784401200	Branch to loc. 7844 if the equal-zero indicator is not on
390792500100	Write alphanumerically on typewriter from loc. 07925
Symbolic Assembly Language (SPS)	
BEZ OUT	Branch to loc. OUT if the equal-zero indicator is on
AM LOC,10	Add 10 to the field at loc. LOC
CM LOC,END	Compare field at LOC with value of END
BNE COMP	Branch to loc. COMP if equal-zero indicator is not on
WATY MESS	Write alphanumerically on typewriter from loc. MESS
Algebraic Compiler Language (FORTRAN)	
READ 12,A,X	Read the values of A and X according to format 12
C=A*X-10.	Replace C by the value of the expression Ax-10.
PRINT 10,C	Print C according to format 10
IF(C)14,14,26	If C is positive, go to statement 26; otherwise to 14
Problem Oriented Language (COGO)	
STORE 25 1000. 2000.	Store the coordinates (1000.,2000.) of point 25
LOCATE 25 39 124. 45 0 0	Locate pt. 25 given distance (124.) and direction (45°0'0") from 39
INTERSECT 24 15 25 39 87	Locate pt. 24 as the intersection of line 15-25 with line 39-87
AREA 5 39 25 87 5	Compute area of polygon bounded by points 5,39,25,87,5

Fig. 1—Examples of various levels of programming languages.



```
START HARRY F. HOLT COGO STUDENT PROBLEM
CLEAR                  1 999
STORE                  1 1500.0 1000.0
                       2 2400.0 2300.0
                       3 1620.0 2430.0
LOCATE/AZIMUTH         1 12 80.0 154 00 00
                       2 10 140.0 225 00 00
AZ/INTERSECT           11 12 64 00 00 10 135 00 00
LOCATE/LINE            11 12 14 890.0
                       14 12 13 300.0
LOCATE/ANGLE           12 13 26 90.0 -9000 00
LOCATE/AZIMUTH         3 31 70. 8 00 00
                       31 24 60. 8 00 00
AZ/INTERSECT           16 24 278 00 00 14 80 00 00
                       19 24 98 00 00 11 135 00 00
LOCATE/LINE            11 19 21 3000.
ALIGNMENT              500 12 14 16 13 91 15 0.0 300.0 0.0 0.0
OFFSET/ALIGN           22 14
ALIGNMENT              501 14 16 24 15 92 17 0. -1. 0.0
OFFSET/ALIGN           2316
ALIGNMENT              502 17 19 21 18 93 20 0. 0. -1. 200.
OFFSET/ALIGN           25 19
LOCATE/LINE            15 91 28 60.0
                       22 91 27 60.
                       1792 30 60.
                       2392 29 60.
                       18 93 32 60.
                       25 93 33 60.
                       209334 90.0
AREA                   13   11 19 20 34 33 32 31 30 29 2827 26 13
DUMP                   1 999
FINISH
```

Fig. 2—Sample student problem assigned to freshman section of computer course and sample student program in COGO. Only complaint received was that problem was too simple, even though this was the first COGO problem assigned to the freshman group.



```
OSTORE                    5  70143.0  81122.0          POINT A
O:                      POINT 1 = O AT THE CENTERLINE INTERSECTION OF ROUTE
O:                        AND THE SOUTH BOUND ROADWAY
O:                      ROUTE 9 CENTERLINE STATION 249+13.14= 80+17.06  BASE
O:                               STATION OF SOUTH BOUND ROADWAY
OLOCATE/BEARING         1  2  1350.97  4  6 49 19
 PT=  2   YCOORD= 70915.213   XCOORD= 81437.092
O                       1  3  958.94  4  6 49 19
 PT=  3   YCOORD= 70525.959   XCOORD= 81483.659
O                       1  4  700.14  3  89 11 56
 PT=  4   YCOORD= 69564.019   XCOORD= 80897.494
OINVERSE/BEARING        4  5
 FROM POINT     4 TO POINT     5 DISTANCE=    620.985   BEARING= N  21 11 39.486 E
 O                        5  3
 FROM POINT     5 TO POINT     3 DISTANCE=    526.740   BEARING= N  43 21 41.398 E
 OALIGNMENT               500  4  5  3  6  8  7  595.0  0.  80.78  0.0
 ID NO.=500   RADIUS=    595.000   SIGN= 1   TANGENT=   116.558   DEFLECTION ANGLE
  TANGENT SECTION LENGTH=   504.427   PC=   585.207   PT=   815.407
 PT=  6   YCOORD= 70034.326   XCOORD= 81079.860
 PT=  7   YCOORD= 70227.741   XCOORD= 81202.027
 PT=  8   YCOORD= 69819.214   XCOORD= 81634.614
OCOORD/POA                37  645.78  500
 YOU GAVE MORE DATA THAN IS NECESSARY FOR THE COMMAND JUST PROCESSED
OLOCATE/BEARING         1  9  958.14  3  89 11 56
 PT=  9   YCOORD= 69560.411   XCOORD= 80639.520
OLOCATE/ANGLE           1  9  19  46.0  -90 00 00
 PT= 19   YCOORD= 69606.406   XCOORD= 80638.876
O                       1  9  10  48.0  -90 00 00
 PT= 10   YCOORD= 69608.406   XCOORD= 80638.848
OLOCATE/BEARING           10  20  2.0  4  7  11  30
 PT= 20   YCOORD= 69610.390   XCOORD= 80638.597
O:                        20= POINT OF CURVE 501
O                       10  11  22.0 4  7 11 30
 PT= 11   YCOORD= 69630.232   XCOORD= 80636.093
O                       1  23  1200.0  3  89 11 56
 PT= 23   YCOORD= 69557.029   XCOORD= 80397.68

OLOCATE/ANGLE             1  23  24  54.0  -90 00 00
 PT= 24   YCOORD= 69611.023   XCOORD= 80396.928
OBR/INTERSECT             25 11 3 82 48
30 24 1 89 11 56
 PT= 25   YCOORD= 69612.390   XCOORD= 80494.694
O:                        NO. 25= PI CURVE 503
OALIGNMENT
  503  24  25  11  26  28  27  2500.0  0.0  0.0  0.0
 ID NO.=503   RADIUS=  2500.000   SIGN=-1   TANGENT=   139.584   DEFLECTION ANGLE
  TANGENT SECTION LENGTH=   -41.807   PC=   -41.807   PT=   237.070
 PT= 26   YCOORD= 69610.438   XCOORD= 80355.124
 PT= 27   YCOORD= 69629.864   XCOORD= 80633.180
 PT= 28   YCOORD= 72110.194   XCOORD= 80320.191
OPARALLEL/LINE            4  5  -27.0  29  30
 PT= 29   YCOORD= 69573.779   XCOORD= 80872.320
 PT= 30   YCOORD= 70152.761   XCOORD= 81096.826
OPOINTS/INTERSECT         31   25   11   30   29
 PT= 31   YCOORD= 69664.479   XCOORD= 809READY.
```

Fig. 3—Sample of portion of 7090 COGO output recorded by teletypewriter.

```
STRUCTURE  SEE ELEM. STR. MECHANICS, TUNG AU, PAGE 240
NUMBER OF JOINTS,    7
NUMBER OF SUPPORTS, 3
NUMBER OF MEMBERS, 12
TYPE  SPACE TRUSS
METHOD  STIFFNESS
JOINT 1 COORDINATES, 0.0, 0.0, 0.0
JOINT 2 COORDINATES, 8.0, 0.0, 4.0
JOINT 3 COORDINATES, 8.0, 0.0,-4.0
JOINT 4 COORDINATES, 0.0, 8.0, 0.0
JOINT 5 COORDINATES, 4.0, 8.0, 2.0
JOINT 6 COORDINATES, 4.0, 8.0,-2.0
JOINT 7 COORDINATES, 0.0,16.0, 0.0
MEMBER  1 FROM 1 TO 4,PRISMATIC, 1.0
MEMBER  2 FROM 1 TO 5,PRISMATIC, 1.0
MEMBER  3 FROM 1 TO 6,PRISMATIC, 1.0
MEMBER  4 FROM 2 TO 5,PRISMATIC, 1.0
MEMBER  5 FROM 2 TO 6,PRISMATIC, 1.0
MEMBER  6 FROM 3 TO 6,PRISMATIC, 1.0
MEMBER  7 FROM 4 TO 5,PRISMATIC, 1.0
MEMBER  8 FROM 5 TO 6,PRISMATIC, 1.0
MEMBER  9 FROM 6 TO 4,PRISMATIC, 1.0
MEMBER 10 FROM 4 TO 7,PRISMATIC, 1.0
MEMBER 11 FROM 5 TO 7,PRISMATIC, 1.0
MEMBER 12 FROM 6 TO 7,PRISMATIC, 1.0
NUMBER OF LOADINGS, 1
LOADING  SEE EXAMPLE IN BOOK
PRINT  MEMBER FORCES
PRINT  MEMBER DISTORTIONS
PRINT  JOINT DISPLACEMENTS
PRINT  REACTIONS
JOINT 4 LOADS,  -8.0,   0.0,   0.0
JOINT 6 LOADS,   0.0, -48.0  -8.0
JOINT 7 LOADS, -16.0,   0.0,   4.0
SOLVE
```

Fig. 4—Sample input to the STRESS System for a simple test problem which illustrates the types of commands in the basic system. Total computer time required for this problem was 2 sec.

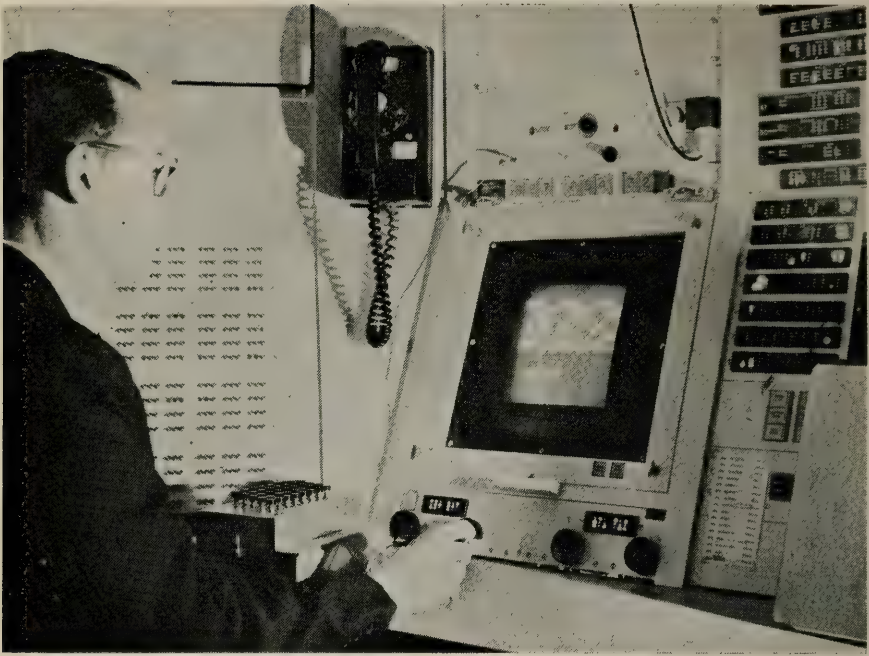


Fig. 5—The Sketchpad System allows the engineer to sketch a structural frame on a CRT with a lightgun, apply loads, and immediately observe the stresses, deflections, and behavior of the structure. The design may be quickly and easily altered to observe the effects of a modification. Sketchpad would be an ideal input system to use in conjunction with the STRESS System. (Photo courtesy of M. I. T. Lincoln Laboratory)

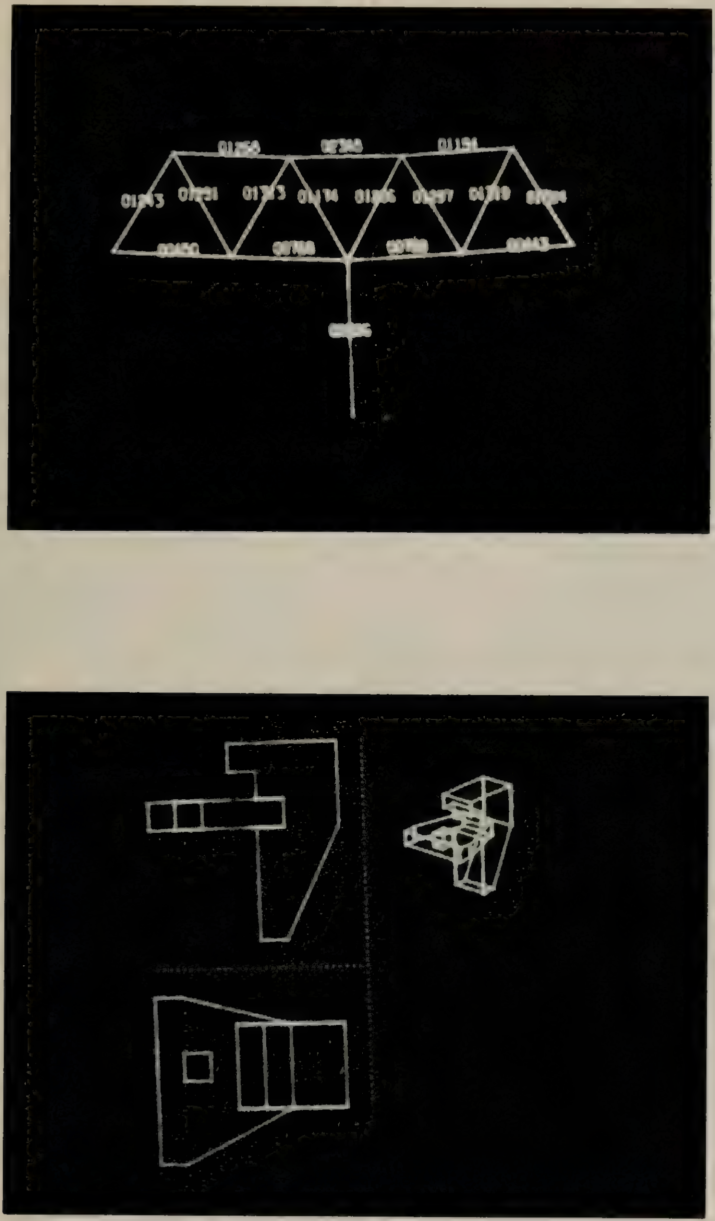


Fig. 6—Photocopy of scope display from Sketchpad System showing stresses resulting from application of load via lightpen to a truss, and views of a mechanical part being designed on-line with the computer.

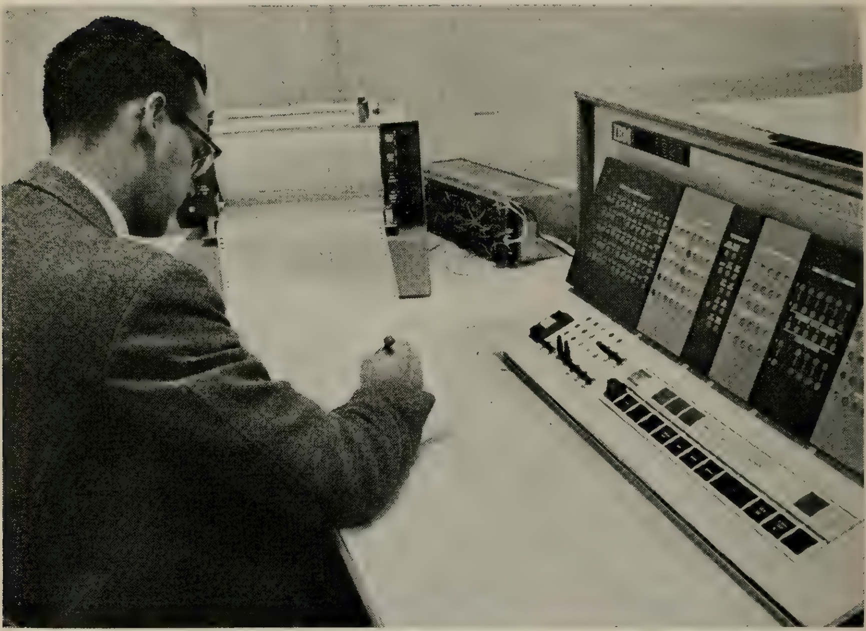


Fig. 7—A low-cost graph plotter used on-line with the IBM 1620 in the Department of Civil Engineering has demonstrated the value of a simple graphical output device in a wide range of civil engineering applications for immediate evaluation of results.

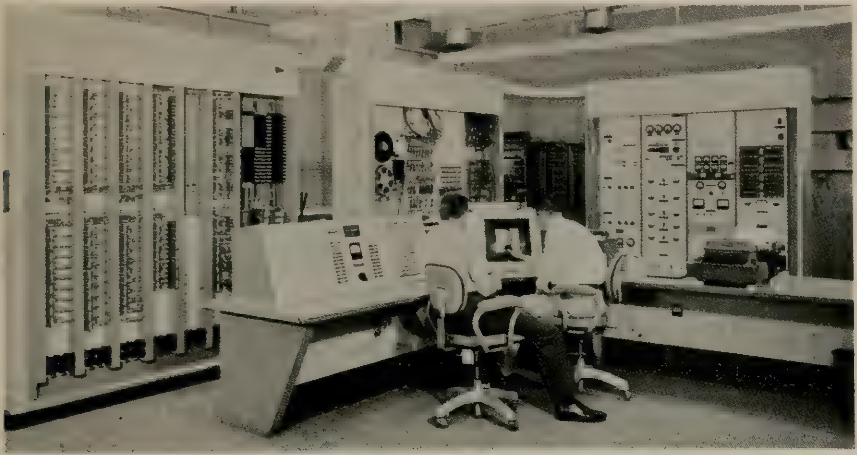


Fig. 8—Scope and light-pen techniques for graphical communication with computers are the subject of extensive research activity in the Department of Electrical Engineering at M. I. T.

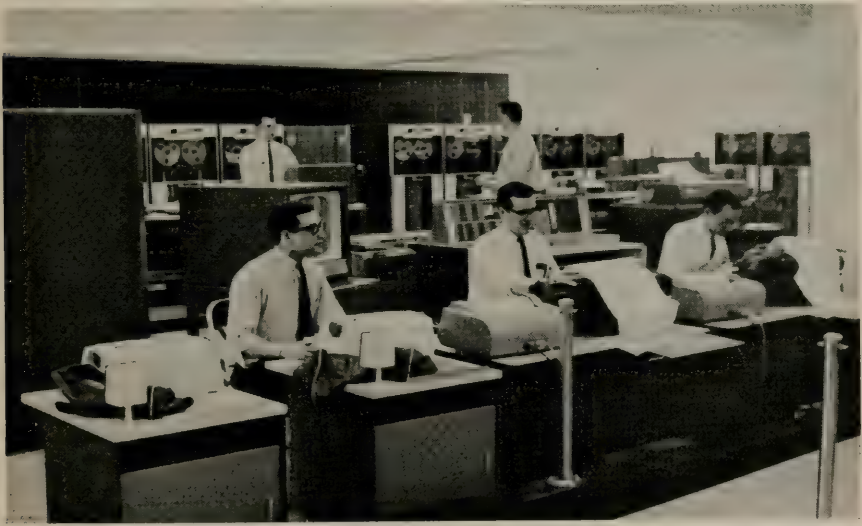


Fig. 9—Photo of the M. I. T. Computation Center showing typewriter units being used as individual user consoles for time-sharing experiments.

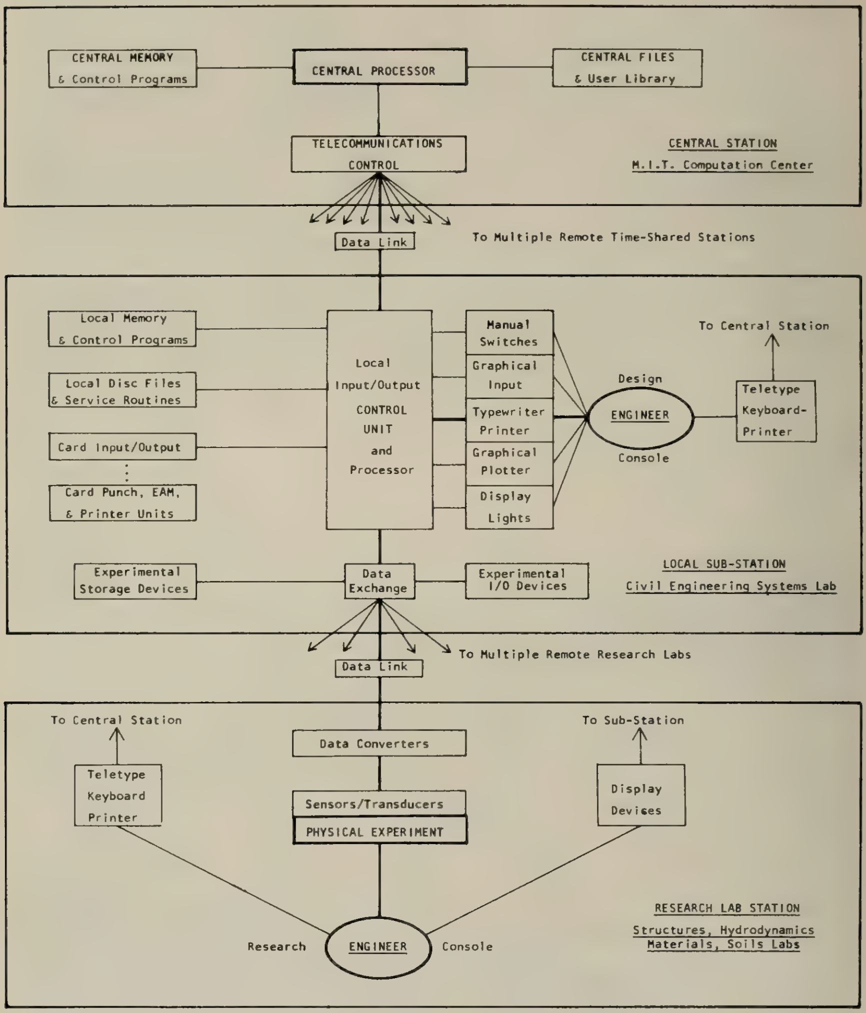


Fig. 10—Diagrammatic view of the principal components in M. I. T. time-sharing system of computer usage, with emphasis on components at the local level in the Department of Civil Engineering. An expanded IBM 1620 serves as the local input/output control and processor which is linked to the IBM 7090 in the Computation Center via a Dataphone link.

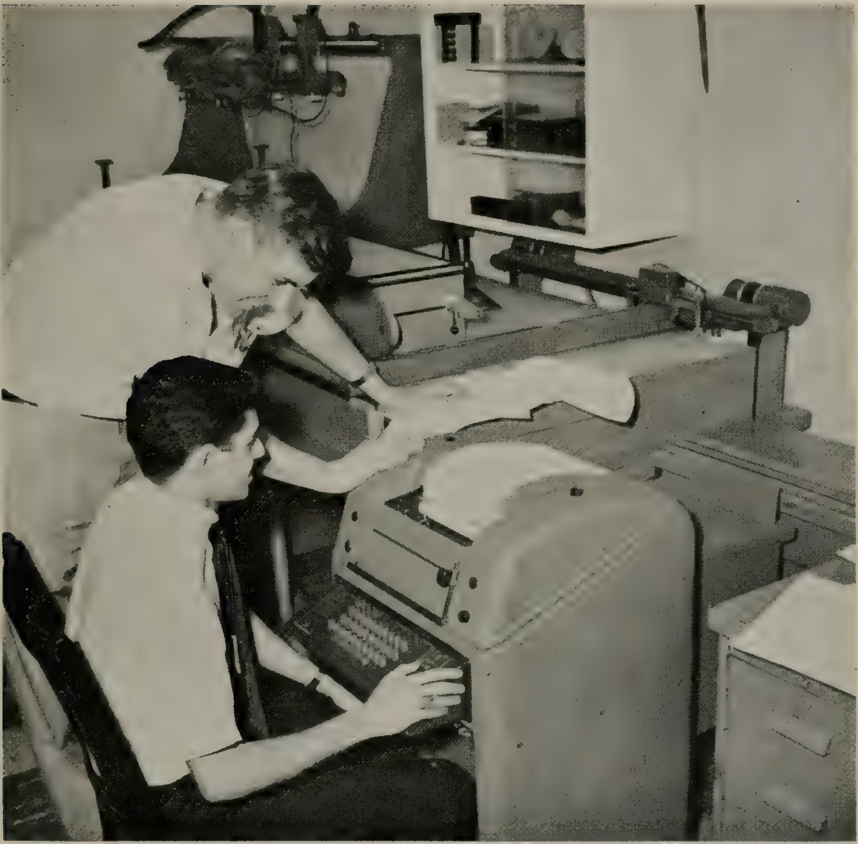


Fig. 11—Standard Teletype unit serves as a minimum remote console in use for experiments on civil engineering applications of a time-shared IBM 7090.

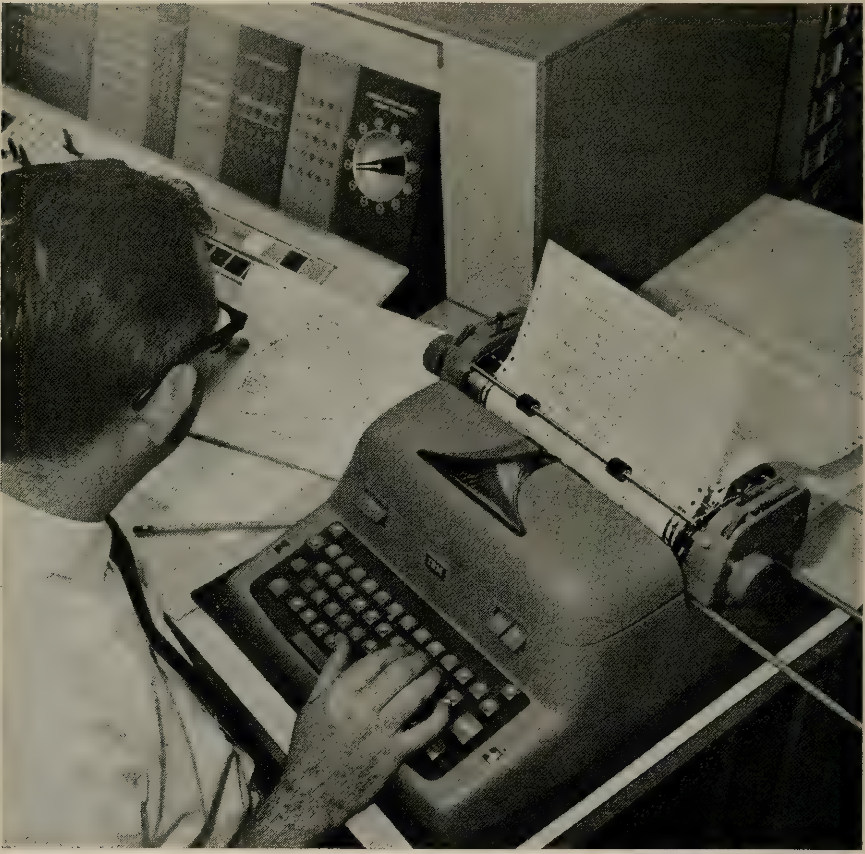


Fig. 12—In the M. I. T. experiments, the IBM 1620 will serve as an interim design console and input-/output device for research on computer methods which require close man-machine interaction.

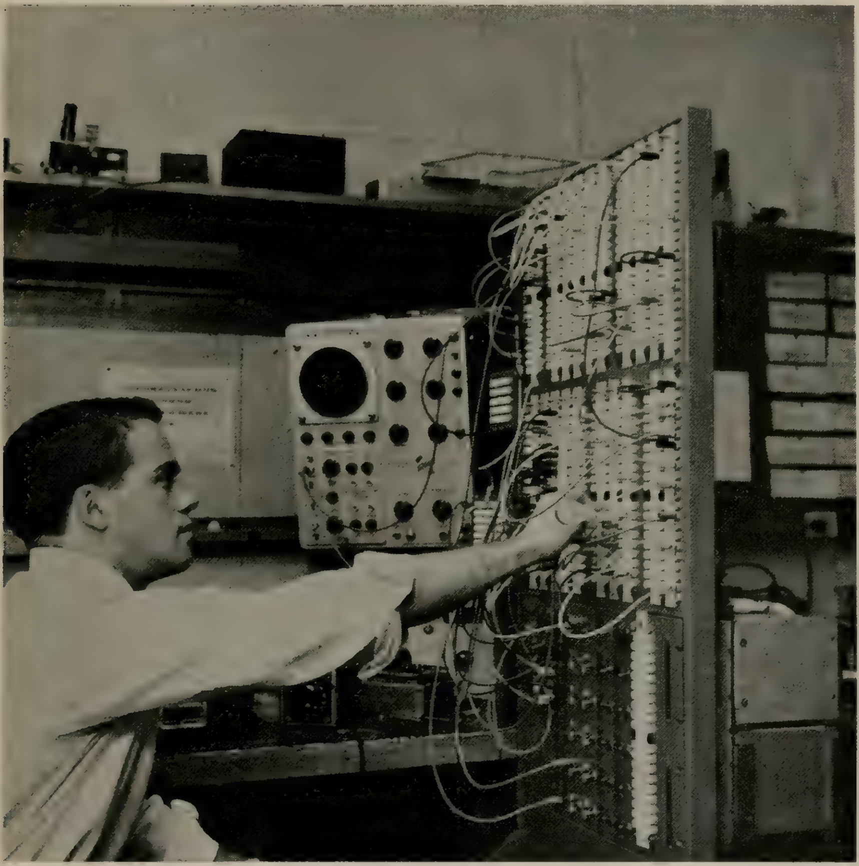


Fig. 13—Data exchange interface under construction in the Department of Civil Engineering for linking IBM 1620 with IBM 7090, research experiments, and special purpose input/output devices. It was designed by E. P. Gladding for maximum flexibility as an information system component.

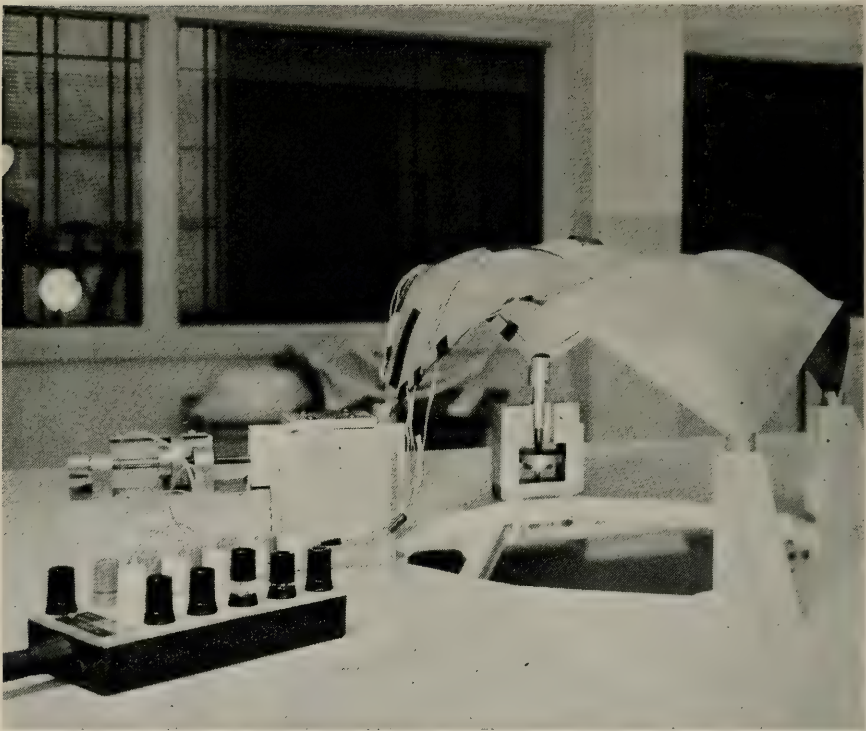
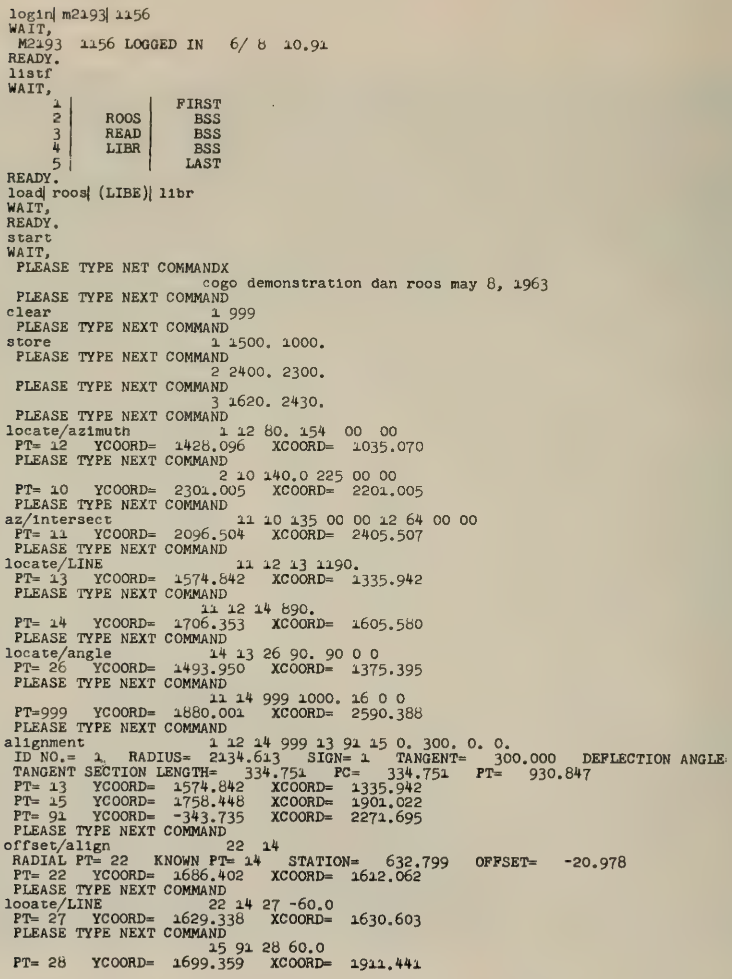


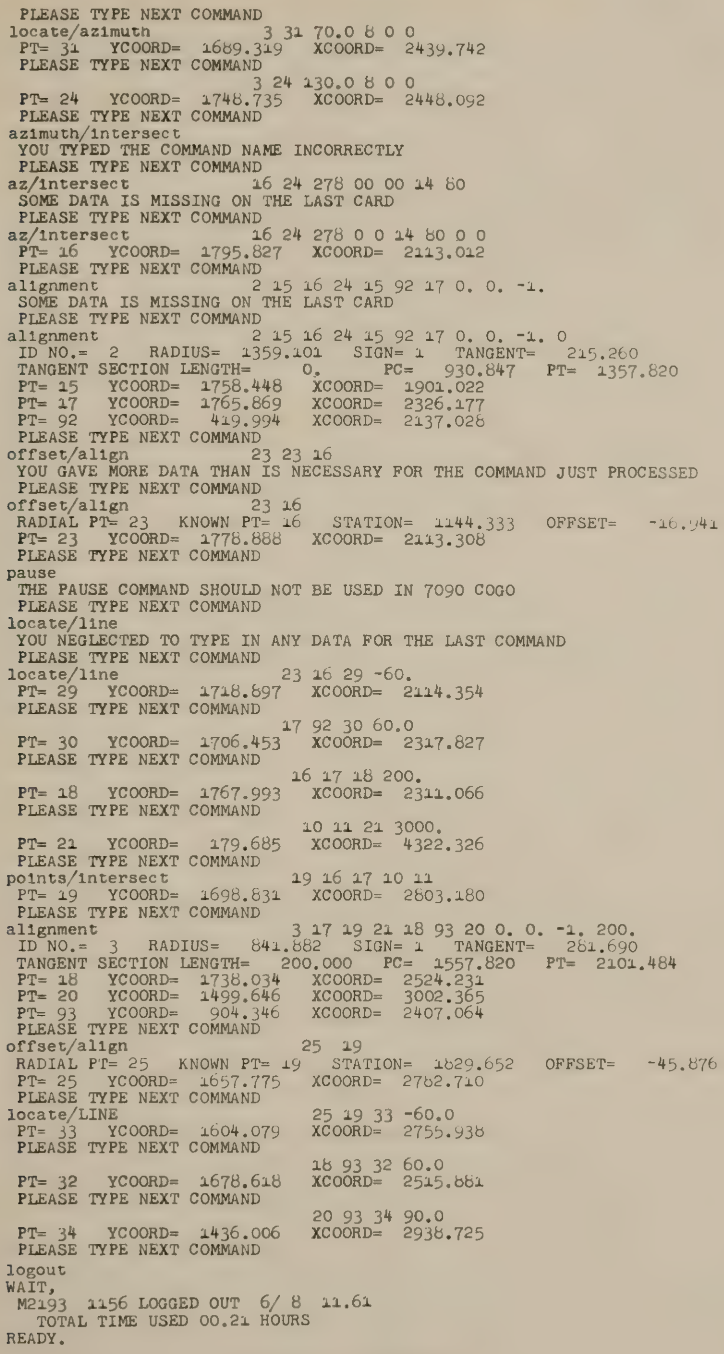
Fig. 14—Current research is aimed at the development of systems and techniques which will allow experimental data originating in the Laboratory for Structural Models to be transmitted directly to the time-shared computer. By means of a console in the laboratory, the engineer would have full control of the computer, instructing it via problem-oriented commands.

Fig. 15—Computer-oriented systems for highway location and design, such as the Digital Terrain Model System, which have been developed at M. I. T. are being adapted to the problem-oriented language and time-sharing approach to permit closer man-machine interaction in the evaluation of location and design decisions.



```
login| m2193| 1156
WAIT,
 M2193  1156 LOGGED IN   6/ 8  10.91
READY.
listf
WAIT,
     1 |         |  FIRST
     2 |    ROOS |    BSS
     3 |    READ |    BSS
     4 |    LIBR |    BSS
     5 |         |   LAST
READY.
load| roos| (LIBE)| libr
WAIT,
READY.
start
WAIT,
 PLEASE TYPE NET COMMANDX
                      cogo demonstration dan roos may 8, 1963
 PLEASE TYPE NEXT COMMAND
clear                  1 999
 PLEASE TYPE NEXT COMMAND
store                  1 1500. 1000.
 PLEASE TYPE NEXT COMMAND
                       2 2400. 2300.
 PLEASE TYPE NEXT COMMAND
                       3 1620. 2430.
 PLEASE TYPE NEXT COMMAND
locate/azimuth          1 12 80. 154  00  00
 PT= 12   YCOORD=  1428.096   XCOORD=  1035.070
 PLEASE TYPE NEXT COMMAND
                        2 10 140.0 225 00 00
 PT= 10   YCOORD=  2301.005   XCOORD=  2201.005
 PLEASE TYPE NEXT COMMAND
az/intersect              11 10 135 00 00 12 64 00 00
 PT= 11   YCOORD=  2096.504   XCOORD=  2405.507
 PLEASE TYPE NEXT COMMAND
locate/LINE               11 12 13 1190.
 PT= 13   YCOORD=  1574.842   XCOORD=  1335.942
 PLEASE TYPE NEXT COMMAND
                      11 12 14 890.
 PT= 14   YCOORD=  1706.353   XCOORD=  1605.580
 PLEASE TYPE NEXT COMMAND
locate/angle           14 13 26 90. 90 0 0
 PT= 26   YCOORD=  1493.950   XCOORD=  1375.395
 PLEASE TYPE NEXT COMMAND
                       11 14 999 1000. 16 0 0
 PT=999   YCOORD=  1880.001   XCOORD=  2590.388
 PLEASE TYPE NEXT COMMAND
alignment              1 12 14 999 13 91 15 0. 300. 0. 0.
 ID NO.=  1   RADIUS=  2134.613   SIGN= 1   TANGENT=   300.000   DEFLECTION ANGLE
 TANGENT SECTION LENGTH=   334.751   PC=   334.751   PT=   930.847
 PT= 13   YCOORD=  1574.842   XCOORD=  1335.942
 PT= 15   YCOORD=  1758.448   XCOORD=  1901.022
 PT= 91   YCOORD=  -343.735   XCOORD=  2271.695
 PLEASE TYPE NEXT COMMAND
offset/align             22  14
 RADIAL PT= 22   KNOWN PT= 14   STATION=   632.799   OFFSET=   -20.978
 PT= 22   YCOORD=  1686.402   XCOORD=  1612.062
 PLEASE TYPE NEXT COMMAND
looate/LINE            22 14 27 -60.0
 PT= 27   YCOORD=  1629.338   XCOORD=  1630.603
 PLEASE TYPE NEXT COMMAND
                       15 91 28 60.0
 PT= 28   YCOORD=  1699.359   XCOORD=  1911.441
```

Fig. 16—Sample of portion of typewriter log from use of COGO system in time-sharing mode on the IBM 7090. Commands in lower-case letters and data on the same line were typed by the engineer. Upper case messages and end results on lines following a command represent response of computer. Note error messages which alert the engineer for immediate corrective action before the problem continues.



```
 PLEASE TYPE NEXT COMMAND
locate/azimuth           3 31 70.0 8 0 0
 PT= 31   YCOORD=  1689.319   XCOORD=  2439.742
 PLEASE TYPE NEXT COMMAND
                        3 24 130.0 8 0 0
 PT= 24   YCOORD=  1748.735   XCOORD=  2448.092
 PLEASE TYPE NEXT COMMAND
azimuth/intersect
 YOU TYPED THE COMMAND NAME INCORRECTLY
 PLEASE TYPE NEXT COMMAND
az/intersect            16 24 278 00 00 14 80
 SOME DATA IS MISSING ON THE LAST CARD
 PLEASE TYPE NEXT COMMAND
az/intersect            16 24 278 0 0 14 80 0 0
 PT= 16   YCOORD=  1795.827   XCOORD=  2113.012
 PLEASE TYPE NEXT COMMAND
alignment               2 15 16 24 15 92 17 0. 0. -1.
 SOME DATA IS MISSING ON THE LAST CARD
 PLEASE TYPE NEXT COMMAND
alignment               2 15 16 24 15 92 17 0. 0. -1. 0
 ID NO.=  2   RADIUS=  1359.101   SIGN= 1   TANGENT=   215.260
 TANGENT SECTION LENGTH=     0.       PC=   930.847   PT=  1357.820
 PT= 15   YCOORD=  1758.448   XCOORD=  1901.022
 PT= 17   YCOORD=  1765.869   XCOORD=  2326.177
 PT= 92   YCOORD=   419.994   XCOORD=  2137.028
 PLEASE TYPE NEXT COMMAND
offset/align            23 23 16
 YOU GAVE MORE DATA THAN IS NECESSARY FOR THE COMMAND JUST PROCESSED
 PLEASE TYPE NEXT COMMAND
offset/align            23 16
 RADIAL PT= 23   KNOWN PT= 16   STATION=  1144.333   OFFSET=    -16.941
 PT= 23   YCOORD=  1778.888   XCOORD=  2113.308
 PLEASE TYPE NEXT COMMAND
pause
 THE PAUSE COMMAND SHOULD NOT BE USED IN 7090 COGO
 PLEASE TYPE NEXT COMMAND
locate/line
 YOU NEGLECTED TO TYPE IN ANY DATA FOR THE LAST COMMAND
 PLEASE TYPE NEXT COMMAND
locate/line                23 16 29 -60.
 PT= 29   YCOORD=  1718.897   XCOORD=  2114.354
 PLEASE TYPE NEXT COMMAND
                           17 92 30 60.0
 PT= 30   YCOORD=  1706.453   XCOORD=  2317.827
 PLEASE TYPE NEXT COMMAND
                            16 17 18 200.
 PT= 18   YCOORD=  1767.993   XCOORD=  2311.066
 PLEASE TYPE NEXT COMMAND
                             10 11 21 3000.
 PT= 21   YCOORD=   179.685   XCOORD=  4322.326
 PLEASE TYPE NEXT COMMAND
points/intersect            19 16 17 10 11
 PT= 19   YCOORD=  1698.831   XCOORD=  2803.180
 PLEASE TYPE NEXT COMMAND
alignment                   3 17 19 21 18 93 20 0. 0. -1. 200.
 ID NO.=  3   RADIUS=   841.882   SIGN= 1   TANGENT=   281.690
 TANGENT SECTION LENGTH=  200.000   PC=  1557.820   PT=  2101.484
 PT= 18   YCOORD=  1738.034   XCOORD=  2524.231
 PT= 20   YCOORD=  1499.646   XCOORD=  3002.365
 PT= 93   YCOORD=   904.346   XCOORD=  2407.064
 PLEASE TYPE NEXT COMMAND
offset/align                 25  19
 RADIAL PT= 25   KNOWN PT= 19   STATION=  1829.652   OFFSET=    -45.876
 PT= 25   YCOORD=  1657.775   XCOORD=  2782.710
 PLEASE TYPE NEXT COMMAND
locate/LINE                   25 19 33 -60.0
 PT= 33   YCOORD=  1604.079   XCOORD=  2755.938
 PLEASE TYPE NEXT COMMAND
                              18 93 32 60.0
 PT= 32   YCOORD=  1678.618   XCOORD=  2515.881
 PLEASE TYPE NEXT COMMAND
                              20 93 34 90.0
 PT= 34   YCOORD=  1436.006   XCOORD=  2938.725
 PLEASE TYPE NEXT COMMAND
logout
WAIT,
 M2193  1156 LOGGED OUT  6/ 8  11.61
   TOTAL TIME USED 00.21 HOURS
READY.
```

Fig. 16 (continued)

Advance Report of Committee 16—Economics of Railway Location and Operation

Report on Assignment 6

Features of Economic and Engineering Interest in the Study. Design, Construction and Operation of New Railway Line Projects, or Major Line Relocations, Proposed, in Progress, or Recently Completed

H. L. Woldridge (chairman, subcommittee), A. N. Brauer, J. L. Charles, S. B. Gill, L. W. Haydon, H. C. Hutson, G. A. Jacob, H. A. Lind, R. McCann, F. N. Nye, F. J. Richter, T. M. Scott, W. P. Shoemaker, G. S. Sowers.

Construction of the Great Slave Lake Railway

By J. L. CHARLES
Consulting Engineer, Canadian National Railways

THE OBJECTIVE

The Government of Canada recently commissioned the Canadian National Railways to construct the Great Slave Lake Railway, to operate it, and to assist in the long-range development of the "Northlands" by providing economical transportation, particularly of heavy bulk commodities, through Northern Alberta to Great Slave Lake and beyond to the Arctic Ocean. The cost of construction was not to exceed $86,250,000.

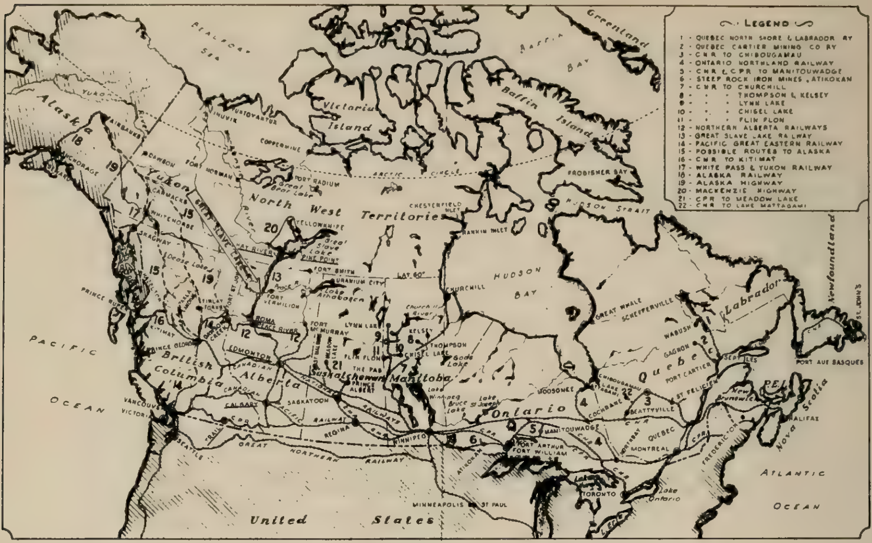
In planning for the objective of economical transportation, estimates had to be made of capital expenditures and costs of maintenance and operation in relation to potential resources. Reconnaissance of the area to ascertain sources of established and long range potential traffic was the first step. Then, all possible routes had to be studied to find the most practical one with respect to the overall objective.

Since the economic advantage of a railway is its ability to haul heavy bulk tonnage with a minimum of power and cost, the ruling gradient in relation to the tonnage to be hauled was the primary feature to be established. Factors affecting the ruling gradient are the origin and terminus of the new line, all intermediate sources of traffic, controlling topographical features and distances between them. The length of the proposed line is directly affected by the ruling gradient. Other factors to be considered when comparing routes are rate and amount of curvature, and "rise and fall."

GENERAL ROUTE

During 1957 reconnaissance was carried out in the country northerly of Fort McMurray, Alta., via Lake Athabasca and Fort Smith to Great Slave Lake; also, from several other points as far west as Fort St. John, B. C. (See accompanying map "Canada—Railways March Northward.") The considerations with respect to present sources of traffic and future potentials affecting selection of the route were:

(1) Establishing rail service to a harbour—Hay River—on the south shore of Great Slave Lake, where freight could be transferred from the railroad to water transport on this large inland lake. From this lake freight would travel



CANADA :~ RAILWAY'S MARCH NORTHWARD

J. L. CHARLES, P. Eng - CANADIAN NATIONAL RAILWAYS
WINNIPEG, MANITOBA OCT. 1960 - REVISED 17 JULY 1963

SCALE IN MILES

on the Mackenzie River to the Arctic Ocean. Hay River, population 1500, is presently served by a gravel-surfaced road known as the Mackenzie Highway. A branch of this road has been built around the west end of Great Slave Lake to the gold-mining town of Yellowknife, population 3800. The distance across Great Slave Lake from Hay River to Yellowknife is 125 miles. The length of the lake, from Hay River northeasterly to Fort Reliance, is 250 miles. From Hay River the tug and barge route on the Mackenzie River extends 1100 to 1200 miles to Inuvik at the delta of this river, and on to Tuktoyaktux on the Arctic Coast. The latitude of Inuvik is near 69 deg. This town is a modern community which was recently built, with the assistance of the Government, to be a service center for Canada's Western Arctic. The length of the water transport season on Great Slave Lake and the Mackenzie River is four months or a little longer—from the end of May to early October.

(2) Providing rail service to Pine Point Mines, said to be one of the largest known bodies of lead and zinc ore. The mines are 50 miles east of Hay River and 10 miles south of Great Slave Lake. Concentrates in the amount of 215,000 tons annually would be hauled 1400 miles through Peace River, Edmonton and Calgary to the smelter at the Consolidated Mining and Smelting Company's plant, near Trail, B. C. Other minerals have been discovered in the Precambrian rocks of the Canadian Shield at the east end of Great Slave Lake, and north of Yellowknife. If these prove to be of economic value, they may be a further source of railway traffic.

(3) Serving the vast first-class agricultural areas which extend northerly for 180 miles from Peace River, through Manning and Keg River, to High Level and 45 miles easterly to Fort Vermilion. Much of this area has been success-

fully cultivated for many years, but development has been restricted by long and costly truck hauls—up to 225 miles—to the nearest marketing facilities—grain elevators and stock yards at Grimshaw.

(4) Hauling forest products—lumber and plywood—which are being manufactured from the stands of good spruce, jack pine, aspen and balsam poplar that are available even as far north as Hay River.

(5) Serving a potential commercial fishing industry. Lake trout and white fish would be hauled to the central and eastern areas of the United States. The permissible annual quota from Great Slave Lake is 9,000,000 lb.

(6) Transporting heavy quantities of gasoline, diesel oil, fuel oil, equipment, reagents and other supplies, required by mining, transportation and other industries located north of Peace River into the areas.

After considering all relevant factors, it was decided that this railway would commence at Roma, a way station on the Northern Alberta Railways, between the towns of Peace River and Grimshaw, at the crest of the 800-ft-deep valley of the Peace River. The line would then run northerly 10 to 15 miles west of and parallel to the Peace River through the agricultural districts of Manning and Keg River for a distance of 180 miles to High Level, where the course of the Peace River turns from north to east, via Fort Vermilion, to Lake Athabasca; thence it would run through the pass between the Caribou Mountains and Watt Mountains to the valley of Hay River, and, via the west bank of this river, past Alexandra and Louise Falls, to a terminus at the town of Hay River. A branch line would extend from a point seven miles south of Hay River, easterly to Pine Point Mines.

One of the factors that influenced location of the railway on the west side of Hay River was that a turn-off for an extension further north into the Mackenzie Valley would be facilitated if such a line is required in the future.

The Government of Canada at Ottawa approved this route on November 23, 1960, and instructed the Canadian National to stake a location on the ground. Fig. 1 shows the general direction of this route, also the principal rivers and localities where traffic is expected to develop.

DESIGN AND LOCATION SURVEYS

Immediately after authority to locate the railway was received, a light helicopter was chartered so that a close reconnaissance could be carried out to ascertain the principal topographical and relative control features, in preparation for commencing ground surveys in January 1961. All location surveys, both field and office work, were carried out by Canadian National personnel.

Gradient Controls

The initial step was to establish the maximum gradient. The principal controlling features affecting "rise and fall" were:

(1) Elevation 1870 at the point of turn-off from the Northern Alberta.

(2) Summit, elevation 2110, at Mile 8.

(3) Whitemud, Notikewin, Hotchkiss and Meikle Rivers in deeply eroded valleys. The bed of the latter is at elevation 1390. All flow easterly into the Peace River.

(4) Summit through the Hawk Hills at Mile 107, elevation 1780.

(5) Plain between Keg River, elevation 1340, and High Level, elevation 1080.

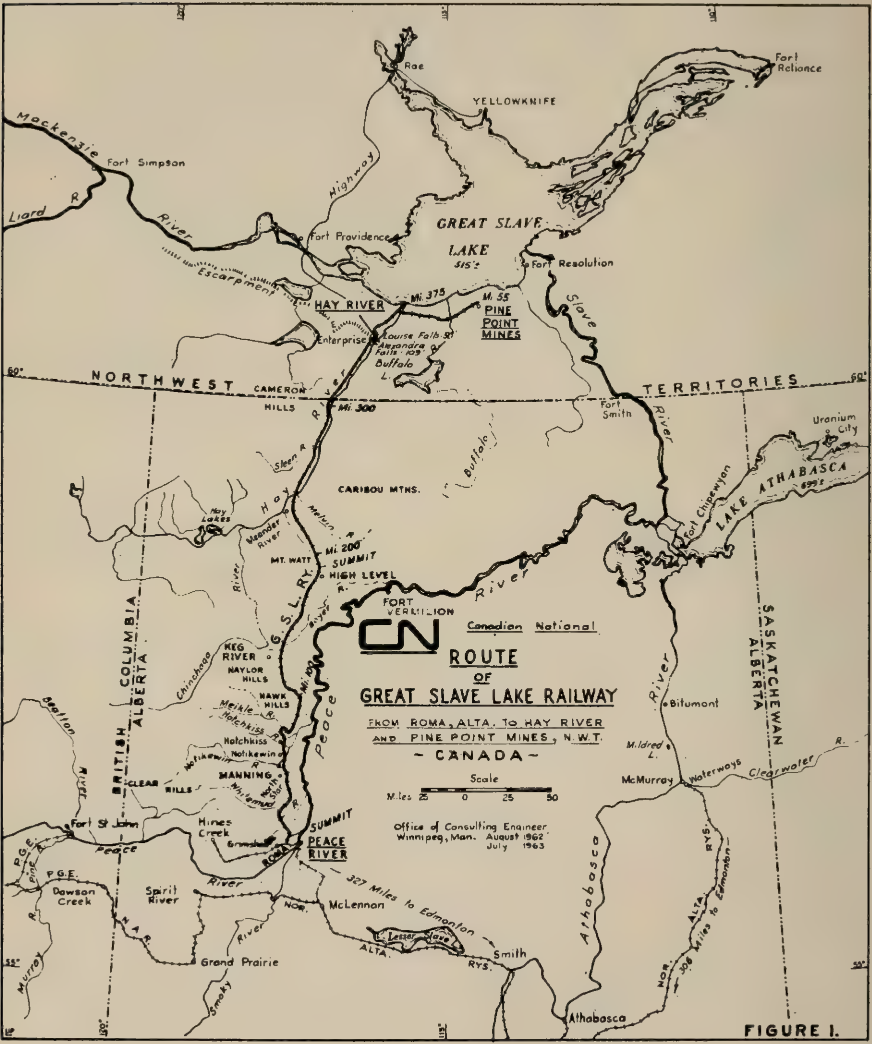
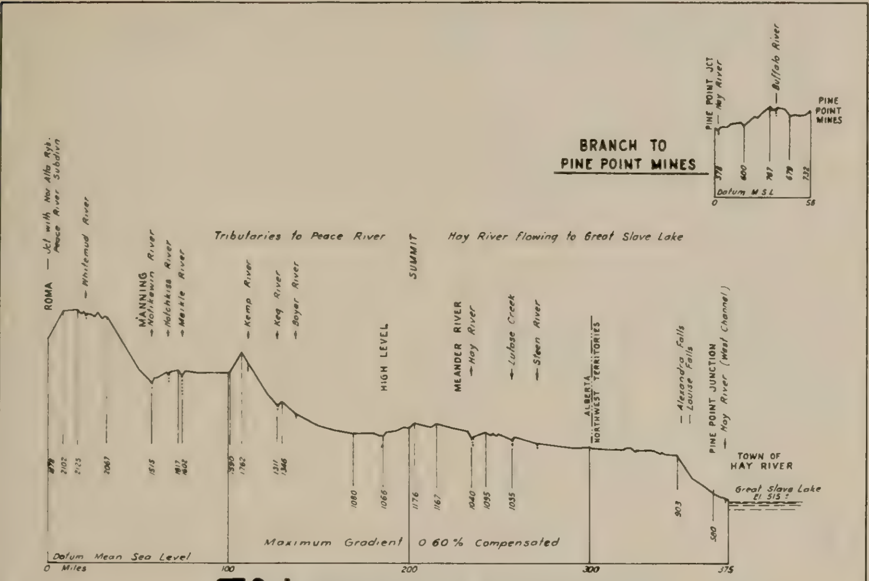

Canadian National
ROUTE
OF
GREAT SLAVE LAKE RAILWAY
FROM ROMA, ALTA. TO HAY RIVER
AND PINE POINT MINES, N.W.T.
- CANADA -
Scale
Miles 25 0 25 50
Office of Consulting Engineer
Winnipeg, Man. August 1962
July 1963
GREAT SLAVE LAKE
515'±
Rae
YELLOWKNIFE
Fort Reliance
Fort Simpson
Mackenzie River
Liard R.
Highway
Fort Providence
Escarpment
HAY RIVER
Mi. 375
Mi. 55
PINE POINT MINES
Fort Resolution
Slave River
Enterprise
Louise Falls
Alexandra Falls
Buffalo L.
NORTHWEST TERRITORIES
60°
CAMERON HILLS
Mi. 300
Fort Smith
Uranium City
LAKE ATHABASCA
699'±
Fort Chipewyan
Steen R.
Hay River
CARIBOU MTNS.
Buffalo
Hay Lakes
Meander River
Melvin R.
Mi. 200
SUMMIT
MT. WATT
HIGH LEVEL
FORT VERMILION
G.S.L. RY.
Boyer R.
KEG RIVER
NAYLOR HILLS
HAWK HILLS
Chinchaga
Meikle R.
Hotchkiss R.
Hotchkiss
Notikewin
Notikewin R.
MANNING
CLEAR HILLS
Whitemud
North Star
Mi. 100
Peace River
Bitumont
Mildred L.
McMurray
Waterways
Clearwater R.
SASKATCHEWAN
ALBERTA
BRITISH COLUMBIA
ALBERTA
Beatton River
Fort St John
Hines Creek
Grimshaw
ROMA
SUMMIT
PEACE RIVER
327 Miles to Edmonton
P.G.E.
Pine R.
Dawson Creek
Spirit River
N.A.R.
NOR.
McLennan
Lesser Slave L.
ALTA. RYS.
Smith
Grand Prairie
Smoky
Murray R.
Athabasca
Athabasca
NOR. ALTA. RYS.
306 Miles to Edmonton
55°
120°
113°
107°

FIGURE I.



GREAT SLAVE LAKE RAILWAY - CANADA
DIAGRAM OF RISE AND FALL

Office of Consulting Engineer
Winnipeg Man August 1962
July 1963

Scales 1" = 40 Miles Horz
600 Feet Vert

FIGURE 2.

(6) Summit between Mile 204 and 209, elevation 1180, between the watershed of the Peace River, which flows easterly to Lake Athabasca, and the upper reaches of Hay River, which flows northerly to Great Slave Lake.

(7) Escarpment in the vicinity of Alexandra and Louise Falls at Mile 348, elevation 900.

(8) Hay River townsite, elevation 525.

(9) Pine Point Mines, elevation 755.

The above control points are shown in Fig. 2.

Study of these principal control points and intermediate features indicated that a maximum gradient of 0.60 percent, compensated for curvature at the rate of 0.04 ft per deg, could be achieved, together with light curvature of 1 to 4 deg, except for a few of 6 deg.

The line was located on this basis, which made the railroad to Hay River 375 miles long and the branch line to Pine Point Mines 55 miles, a total of 430 miles.

The major problems that had to be surmounted in order to locate the line without exceeding 0.60 percent gradient were:

(1) Descending from the east end of Clear Hills to the plain around North Star and Manning. This required careful projection of the maximum gradient continuously for 17 miles.

(2) Crossing the Meikle River Valley at Mile 73. The valley is 300 ft deep and 2 miles wide with banks subject to serious landslides.

(3) Ascending to the summit through Hawk Hills and descending to Keg River, which involved very careful sidehill projection of the maximum gradient for 25 miles.

(4) Crossing the Upper Hay River Valley at Mile 234. The valley is 1 mile wide and 130 ft deep, with difficult sub-soil formations.

(5) Descending the 109-ft-high escarpment at Alexandra Falls, and the 65-ft-high escarpment at Louise Falls, on the Hay River 30 miles south of Great Slave Lake.

(6) Crossing the Lower Hay River and Buffalo River on the branch line to Pine Point.

Survey Methods

Since winter conditions are helpful to travel across extensive areas of muskeg, which would be encountered along the northerly sections of the route, it was decided to commence the location work at the north end of the line. This would permit staking the branch line from near Hay River to Pine Point Mine, where no access roads existed, before the spring break-up in 1961.

Prints of existing aerial photographs, scale 1 ft = 3300 ft, were obtained from the Royal Canadian Air Force, and, with the aid of a helicopter, a bombardier and two bulldozers, an access trail was plowed out through the snow, which averaged 3 ft in depth over the frozen terrain, early in January 1961.

Concurrently a survey party, consisting of 14 men, including a cook, housed in mobile trailers, was moved in, and work was commenced to stake the location center line, which was projected on the aerial photographs after observation from the helicopter. This observation was supplemented by ground inspections at all critical points.

Since most muskegs were avoided, the line was located through country timbered with spruce, jack pine and aspen, 3 to 20 in. in diameter. The line was cleared by the two bulldozers, operating in tandem, at a daily cost of $100 each; the average length of line cleared per working day was four miles.

The operation of bulldozers to clear a line through undeveloped country during winter is very efficient. In addition to being cheaper than using axemen, it facilitates the progress of chainmen and transitmen and the level party. The path plowed through the snow and deadfall eliminates the need for snowshoes, and thus greatly reduces physical effort and time.

On the branch line from Hay River to Pine Point, there are two major rivers to be bridged—the Lower Hay and the Buffalo. Test holes were drilled to ascertain foundation conditions at these bridge sites and also at intervals along the line to determine subsurface conditions before the spring thaw. No unusual depths of organic materials were disclosed. In February 1961, a second party started to work northerly from Roma. The first phase was to establish horizontal and vertical ground stations along the route for control of photogrammetric mapping.

Aerial photography and photogrammetric mapping were employed throughout; contracts for these items were awarded to specialists in these fields. Flight lines were established on general maps, scale 1 in = 4 miles, which were available of the area. Photographs were taken to a scale of 1 in = 1200 ft, which covered a strip 1.75 miles wide. Stereo pairs were studied, and a strip ¼ to ½ mile wide was delineated to be mapped to a scale of 1 in = 400 ft, showing contours at 5 ft vertical intervals. The maps used were original manuscripts. The cost of photography and mapping, excluding ground controls, averaged $90 per line mile. As map sheets were received, the railway center line was projected and the profile plotted. When advisable, alternatives were plotted for comparative studies. Maps and profiles to a horizontal scale of 1 in = 400 ft and vertical scale of 1 in = 20 ft were plotted in the field daily and forwarded periodically to the base office.

After the preliminary reconnaissance by one engineer riding in the helicopter for one month, the general route was delineated for aerial photography and the strip to be mapped was selected. Then the location—430 miles long—was projected, staked, and mapped and the quantities were estimated. This work required 10 months to accomplish, from January through October 1961. Concurrently, two small supplementary parties were set up to make land ties along the southerly section of the line where it runs through developed areas, and to carry out preliminary soil surveys along the entire line.

The cost of location, including the chartering of the aircraft, aerial photography, mapping, labor, accommodation, board, equipment, supplies, fuels and transportation—for both base office and field parties—averaged $1,500 per mile, mostly through undeveloped timbered country. However, access was favorable, as the railway is not more than 8 miles from the Mackenzie Highway—a first-class gravel-surfaced road between Roma and Hay River. There was no road between Hay River and Pine Point.

REGIONAL GEOLOGY AND SOILS SURVEY

Regional Geology

The railway line runs through the northwest part of the Great Plains area of Canada. Bedrock is at some depth, except at the escarpment 30 miles south of Great Slave Lake. The surface geology of the region crossed by the line indicates that all the soils in the vicinity of the line were laid down from glaciers or glacial lakes. The general slope of the land is to the northeast as shown by present river courses. The area was covered in Pleistocene time by successive ice sheets from the northeast which laid down and consolidated a heavy layer of glacial till. When the last ice sheet melted back, meltwaters ponded between the ice and higher land to the southwest, forming a number of glacial lakes. Sediments were laid down in these lakes, but beaches did not have time to form as the lakes found successively lower outlets around the retreating ice and water levels dropped. One of the spillways formed by drainage water from these lakes is presently occupied by Hay River.

Local Soil Deposits

The glacial till was formed by the ice sheets from surface deposits and clay-shale bedrock which underlie most of the area. The till therefore contains 30 to 50 percent of clay minerals, the remainder having been collected by the ice during its passage over the Canadian Shield area. Clay minerals in the till consist mainly of montmorillonite with illite and minor amounts of kaolinite. On the surface of the till, local glacial events deposited moraines and outwash materials which have generally added to surface relief. The resulting irregular ground and poor drainage have encouraged muskegs to form in low areas.

Where lake sediments occur, surface relief is more uniform. The sediments range in depth from a few inches to an occasional maximum of 30 ft and are made up largely of silt and clay.

The escarpment at Mile 348, at Alexandra Falls and Louise Falls on the Hay River, is composed of sedimentary rocks. At one time it formed the southern limits of a large glacial lake which occupied the Great Slave Lake Basin. Dammed by retreating ice, the lake formed a number of beaches considerably above the present lake level. These beaches now appear as sandy ridges running roughly parallel to the shore, blocking drainage and causing muskegs to form between them. The railway branch line running east from the main line to Pine Point follows these ridges.

Soil Survey

A soil survey along the route of the railway was made at the same time as the location survey to ensure, insofar as possible, that no delays to construction work would occur, and to gather a knowledge of the engineering characteristics of the soil materials to help in planning for their optimum use; and, at Meikle River, to assist in establishing the final location of the line.

A power auger mounted on a muskeg tractor was used to bore holes 10 to 12 ft deep at a spacing which ranged from 1,000 ft in woodland areas to 10,000 ft in farming areas. Soil samples were carefully examined and ground-water levels noted. This work was carried out by local drilling contractors and directed by the railways' engineers.

Soil Types

The clay till, which predominated along the route, was found to be similar in gradation and texture over considerable distances. Deposits of silt or sand, or a combination of both, were occasionally found in the till. Lake-deposited silt and clay overlying the till were found to increase in plasticity from Mile 40 to 60 and decrease from Mile 60 to 80, probably indicating that the deepest water in which they were laid down occurred near Mile 60.

MUSKEGS AND PERMAFROST

Extensive areas of muskeg occur throughout this territory, particularly in the northern sections between Keg River and Hay River, but also, between Hay River and Pine Point. Muskegs were circuited where practicable in relation to distance and overall economy of construction, maintenance and operation.

Where permafrost is encountered, construction methods may be affected by the need to maintain the ground in a frozen condition wherever possible; and, where this is not possible, to replace any material which will become incompetent upon thawing.

Since this project is located in Northern Alberta and the Northwest Territories, it was expected that permafrost might be encountered north of latitude 59 deg; however, only very small quantities have been uncovered to date and no large amounts are expected. It is interesting to note the comparatively minor permafrost condition on the Great Slave Lake Railway in contrast to the Hudson Bay Railway, some distance to the southeast in Manitoba, where 150 miles of line across the "Barrens" and "Land of Little Sticks" south of Churchill are constructed entirely on permafrost. This condition has been carefully preserved and track maintenance on it is relatively light. However, permafrost is found in local "islands" as far south as latitude 54 deg; from this latitude northerly through the area of transition to extensive permafrost, maintenance is not accomplished without some difficulties.

ROADBED DESIGN

The roadbed section and construction specifications for the railway line were made to strike a practical relationship between construction and maintenance costs. The standard roadbed section has a 20-ft width between shoulders and 2:1 side slopes for normal embankments and excavations; flatter slopes of 3:1 are required for some high fills and deep excavations. Erosion from rainfall and surface sloughing from frost action, as well as slope stability considerations, influenced the design of slopes.

Specifications call for all fills to be compacted to 95 percent of standard Proctor density. Approval of compaction equipment is given by the engineer on the basis of actual performance. The height of the fills is to be raised about 2 percent of total height at bridge approaches and at other locations where future consolidation settlement would otherwise require extra ballast to be added. Major cut and fill slopes will be seeded and mulched to minimize surface erosion.

Foundation materials for fills are generally satisfactory except for soft soils at some river crossings, and the muskeg areas. It is intended to remove the worst frost-heaving materials below subgrade elevation and replace them with compacted till. However, as it is so important that a railway be so located that it will have a low ruling gradient and that annual charges on investment and expenditures for maintenance and operation be kept to a practical minimum in relation to revenues, location and construction of a railway are not entirely similar to a highway which is not expected to show a tangible balance sheet.

To obtain these major objectives, construction on comparatively inferior ground may be necessary for a railroad at some points which would be avoided in the location of a highway, since highway gradients are more flexible.

CONSTRUCTION

An order in Council dated December 7, 1961, authorized the Canadian National to proceed with construction and to complete the railway line prior to December 31, 1966.

This project is being directed from a base office at Peace River by an engineer of location and construction. He has one assistant engineer, draftsmen, accountants, clerks, etc., and a strong field staff. The total office and field force consists of 100 to 110 people.

For field engineering purposes in connection with grading, culverts and bridges—staking the work preparatory to construction, supervision during progress and final measurement at completion—the line has been divided into sections of up to 50 miles in length, five sections to be opened up at one time.

Each section is directed by a supervising engineer, assisted by two assistant engineers, instrumentmen, rodmen, chainmen, etc. These parties are housed in mobile trailers and are provided with adequate vehicles for transportation.

With a view to obtaining minimum maintenance without involving uneconomic capital expenditures, careful soil surveys, as mentioned previously, have been undertaken, and soils engineers are on the job to advise the supervising engineers with respect to soil mechanics.. In addition, there are two structural engineers who layout and supervise construction of the required bridges.

Railway track-laying and ballasting forces have been organized under the direction of a manager, who reports to the engineer of location and construction. This manager's headquarters is at Roma, where offices and shops have been set up. The track forces will be described later.

Relative to the construction work, it was decided that: (1) materials would be supplied by the railway; (2) clearing, grubbing, grading, installation of culverts and erection of bridges would be carried out by contractors, each contract to cover approximately 50 miles of line as far as clearing, grading and culverts are concerned; bridges would be contracted for separately or by groups of structures, bids to be advertised for on a unit price basis; and (3) track would be laid and ballasted by railway forces.

Schedule

A schedule was set up to complete the project as directed by the Order in Council, which was coordinated with the plans of the Pine Point Mines to ship concentrates in

1966. To prepare for such shipments, skeleton track, followed with a first lift of ballast, will be laid to the mines not later than October 1965.

Clearing, Grading and Culverts

Subject to weather conditions, every effort is being made to complete the subgrade by freeze-up time in 1964. Clearing and bridge work can be carried on throughout the year, but grading in these latitudes is restricted to a short open season of four months—June to October—when it is practicable to excavate cuttings and build relative embankments with earth and other materials which freeze annually. One major item is most critical—to grade the more than 16,000,000 cu yd of material required to build the 430 miles of railway line within 12 available months. There are two classifications of excavation—solid rock, and all other materials. Solid rock is not expected to be encountered except in the immediate vicinity of the escarpment at Mile 348.

Drainage structures consist of 24- to 60-in corrugated iron pipe and 72- to 120-in structural steel plate pipes, placed singly or in multiples, to provide general cross drainage.

Meikle Valley Crossing

The most formidable individual obstacle has been overcome—crossing the Meikle River Valley, 73 miles north of Roma. The Meikle River flows from the Naylor Hills easterly into the Notikewin River which is a tributary to the Peace River. The Meikle has eroded a course relative to the Peace, which flows through a very deep valley.

Where the Great Slave Lake Railway crosses the Meikle River Valley, the valley is 2 miles wide and 300 ft deep, as stated before. Both sides of the Meikle Valley have been broken by a series of large landslides. The condition of the valley in the vicinity of the crossing is illustrated in Fig. 3. Except for occasional terraced areas left by the river in cutting down to its present level, the scars of landslides cover all the valley slopes for many miles upstream and downstream from the crossing. Some slides are kept in an active condition by river erosion at the toe. These are outlined in Fig. 3. It is not practicable to cross the valley without traversing some slide areas, but a careful study of soil conditions helped in choosing the most economical and trouble-free route.

Test borings showed the following sequence of materials underlying prairie level at the crossing:

10 ft of dry lacustrine silt.

200 ft of grey, stiff silty clay till, with some embedded sand and gravel, of medium plasticity, and over-consolidated.

Below this, dark grey stiff clay—highly plastic, heavily over-consolidated, fissured near the top, and laminated at depth.

The stability of existing slopes of undisturbed soil was evaluated from field observations of the slopes and laboratory tests on undisturbed samples. The degree of saturation of the samples taken indicated ground water elevations and *in-situ* pore pressures. Consolidation tests were made to show the amount of preconsolidation and indicate the behavior of the soil in slopes and under pier footings. Unconfined compression tests showed the short-term (end of construction) strength of material in cut slopes. Consolidated, drained tri-axial compression tests were made to predict the effective long-term strength of soil in slopes after the pattern of seepage flow was stabilized.

Since some of the lower slopes of disturbed till are still moving, the opportunity of checking the effective strength of their component soil against that obtained from laboratory tests was utilized. Strength values confirmed in this way were used to predict the behavior of the lower slopes when fills will be placed on them.

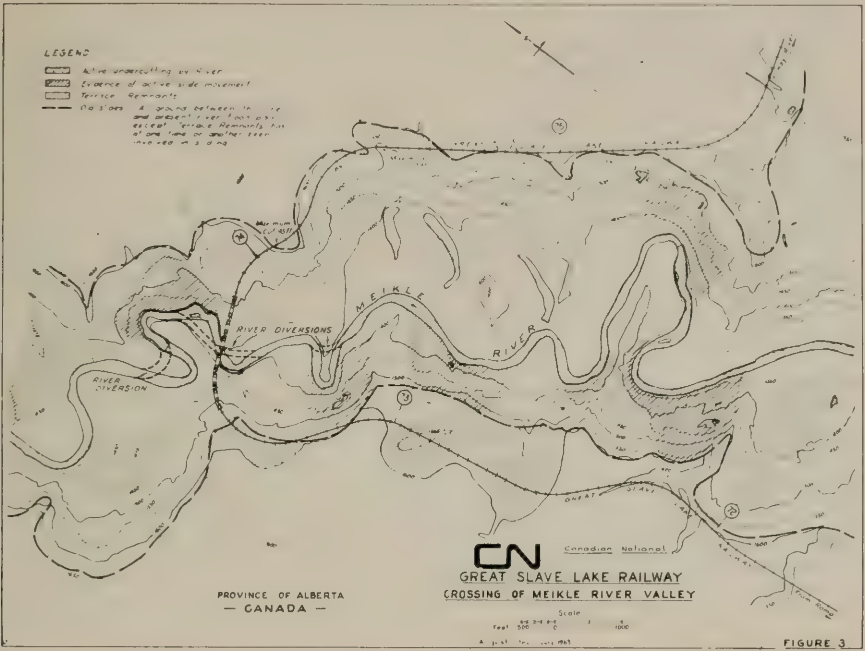


FIGURE 3

The stability of new fills was evaluated by tests on remolded compacted specimens of typical cut materials. Unconfined compression tests showed the relation of shear strength to water content, and consolidated undrained tri-axial tests indicated strength and pore pressure characteristics to be expected in compacted embankments. Total stress analyses using unconfined compression test results were used to show the short-term stability of fill slopes. Effective stress analyses using tri-axial test results were used to show long-term stability.

Families of curves were prepared for embankment fill slopes and for cut slopes in the natural material on both north and south sides of the valley, showing the factor of safety available for different slope angles and heights.

Final location of the railway was made with the assistance of these data, and in the light of all considerations. Three diversions of the river have been excavated to remove the river from locations where it was eroding the toe of slopes adjacent to the line, and the excavated material has been used to form supporting berms against the toes of these slopes. Carefully planned stripping, disposal and drainage have been carried out to protect against further ground movement in the vicinity.

The quantities in the four miles of line crossing the Meikle River Valley are: 1,700,000 cu yd of common excavation, 8200 lin ft of culverts and flumes, 100 acres of seeded slopes, and a bridge 2127 ft long and up to 170 ft high. The bridge is a steel viaduct with concrete substructures. The substructure contains 4050 cu yd of concrete; the superstructure weighs 2170 tons. In its timber-trestle approaches are 3,700 lin ft of piling and 148,000 fbm of timber. Total cost to the subgrade, excluding track, was $2,367,000.

Bridges

All bridges were designed by the staff of the Canadian National's engineer of bridges and structures at System Headquarters in Montreal. Borings at river crossings, supplemented by surface observations, gave the necessary information for the detailed design of the structures. The bridges were designed for Cooper E 60 loading.

Test drilling was usually done with a rotary drill rig mounted on a muskeg tractor. A dry auger was used to advantage where it was important to log water-bearing zones. Soil samples received from the drill inspectors were examined and tested at the site in a trailer-mounted soils testing laboratory operated by the railway's staff. By this means all classification tests and unconfined-strength tests were made on the site, allowing a preliminary appraisal of conditions for the use of the engineer-in-charge to control the drilling and sampling program.

As far north as Mile 200, the rivers have been controlled in their rate of downcutting during post-glacial time by the deep valley of the Peace River to which they are tributary. As a result, they have had opportunity to meander and form relatively wide, terraced valleys, which were studied to good advantage in choosing the location of the crossings.

At most of the bridges the concrete piers were founded on spread footings, except where the height of the pier was such as to impose prohibitive bearing loads on the ground, or where recent sediments are present instead of the usual competent valley bottom materials. Treated timber piles are being used to support the piers in such locations.

The important bridges, with concrete substructures and steel superstructures, are as follows:

(1) Notikewin River—two 105-ft deck plate-girder spans with timber trestle approaches; overall length 43 ft, height up to 65 ft.

(2) Meikle River—1730-ft steel viaduct, including a 150-ft deck-truss center span, with timber trestle approaches; overall length 2127 ft, height up to 170 ft. (See Fig. 4). The timber trestle approaches and concrete pedestals were completed before winter 1962. Track was laid to this site during December 1962 to permit delivery by train of materials and, particularly, a heavy-duty, on-track, erection derrick. The steel superstructure was erected between January and April 1963, during which temperatures at times dropped to 50 F below zero.

(3) Kemp River—Two deck plate-girder spans, one 39 ft 6 in long and the other 59 ft 2 in long, with timber trestle approaches; overall length 553 ft, height up to 65 ft.

(4) Upper Hay River—two 200-ft deck-truss spans, two 40-ft beam spans, with timber trestle approaches; overall length 902 ft, height up to 45 ft.

(5) Steen River—one 105-ft deck plate-girder span, two 30-ft beam spans, with timber trestle approaches; overall length 30 ft, height up to 35 ft.

(6) West Channel Hay River, entering Hay River town—combined highway–railway bridge consisting of two 192-ft through truss spans.

(7) Lower Hay River, combined highway-railway bridge on branch to Pine Point—one 225-ft through truss span and two 159-ft 6-in through truss spans; overall length 554 ft, height 50 ft.

(8) Buffalo River, on branch to Pine Point—one 120-ft deck plate-girder span, two 105-ft deck plate-girder spans and two 40-ft beam spans, with timber trestle approaches; overall length 574 ft, height up to 55 ft.

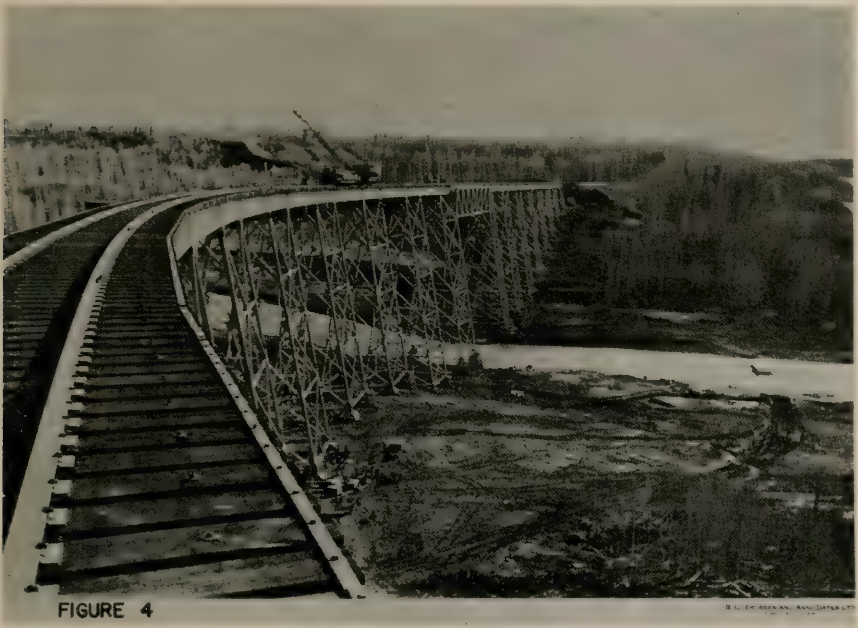


FIGURE 4

Meikle River crossing.

There are also 28 timber trestles with a total length of 3840 ft.

All piles and timber were pressure treated with creosote. Because of the long winter season, with low temperatures, the life of timber is comparatively long, estimated at 45 years.

Rivers in northern latitudes, such as the Hay River, which flows from south to north, may present a dangerous condition during spring break-up and run-off of ice. Break-up occurs in southerly reaches first, and the broken ice flows against a solid formation of ice before there is movement further north. This results in heavy ice jams. This condition occurred in the Hay River during the spring break-up of 1963 and caused a disastrous flood with heavy property damage to Hay River town. Bridges to cross such rivers need to be designed with a minimum number of piers and ample vertical clearance between extreme high water and the superstructure, to avoid any possibility of obstructing the movement of ice.

With the exception of the Meikle River crossing, materials for the bridges were transported by highway from a railhead to the sites to insure completion of the structures ahead of track laying. For this to be practicable, no deck plate-girders longer than 105 ft were incorporated in the designs.

TRACK

Ties are jack pine, 7 in by 9 in by 8 ft, pressure treated with creosote, laid 2880 per mile, and are fully tie plated. Rail is 80 and 85-lb sections released from heavier traffic lines which are being relaid with new rail. Ballast is pit-run gravel and crushed, screened and washed gravel; minimum depth under ties 12 in, cubic yards per mile, 3420.

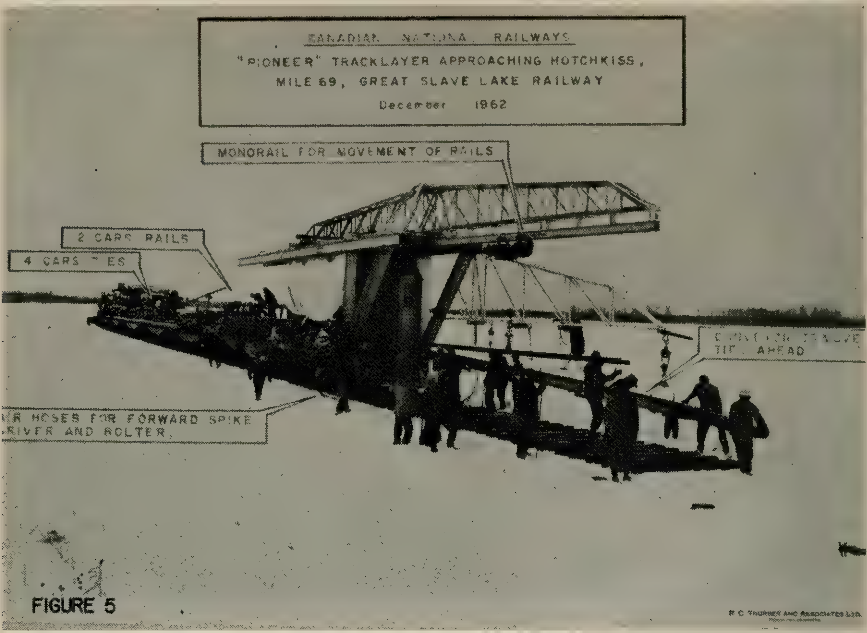

CANADIAN NATIONAL RAILWAYS
"PIONEER" TRACKLAYER APPROACHING HOTCHKISS, MILE 69, GREAT SLAVE LAKE RAILWAY
December 1962
MONORAIL FOR MOVEMENT OF RAILS
2 CARS RAILS
4 CARS TIES
CONVEYOR TO MOVE TIES AHEAD
R HOSES FOR FORWARD SPIKE
RIVER AND BOLTER.
R C THURBER AND ASSOCIATES LTD.

FIGURE 5

The Pioneer

Rail is being laid with a self-propelled on-track machine called the Pioneer which was developed and fabricated by Canadian National personnel. (See Fig. 5). This unit is powered by a diesel engine and is equipped with an electric generator and air compressor to operate conveyors, a travelling crane, impact wrenches and spike drivers. The Pioneer hauls all materials required for one mile of track on seven flat cars—two for rails, four for ties, and one for fastenings—the rails ahead and then the ties.

The ties are brought forward on a line of conveyors attached to the left of the flat cars and to the Pioneer. As the ties arrive at the front of the Pioneer they are placed, together with tie plates, in position on the subgrade. The rails, with splice bars attached, are moved ahead from the flat cars with the travelling crane on an overhead monorail and lowered onto the ties.

Spikes are driven into every fourth tie, and two bolts are placed in each pair of splice bars as each rail is laid. Power tools are used. This is sufficient to support the Pioneer, which propels itself ahead continuously at a uniform speed of 9 to 10 ft per min. On-track mechanical machines follow immediately behind the Pioneer to complete the spike driving and bolting operations.

One mile of track is laid complete in one normal shift with a gang of 50 men. In the North, during long summer days, 1½ to 2 miles may be laid. The Pioneer gang is supported by a small material-yard gang of 10 to 15 men equipped with a self-propelled on-track crane, to load materials at the railhead.

At the end of each shift a full set of loaded flat cars is pushed up to the Pioneer and the empties are switched back. No work train attendance is required during shifts.

Operation of the Pioneer prevents serious rutting of the subgrade and/or suspension of work during wet weather, which may happen when laying track by methods in which ties are hauled ahead with trucks.

Track was laid to the Meikle River Bridge site, Mile 73.6, by December 1962 for delivery of structural steel, and as mentioned previously, a heavy-duty on-track erection derrick. A yard was then established at Hotchkiss, Mile 69, for assembling the ties, rails and fastenings required for the 1963 program. After completion of the Meikle River Bridge, track laying was resumed at the end of May 1963, and carried through to a gravel deposit at Meander, Mile 225, by mid December. Materials required for 1964 were transported over skeleton track on frozen subgrade to the advanced railhead before the spring thaw.

Track laying will proceed in 1964 through to Mile 350, and materials will be stockpiled there as required to complete the track to Hay River and Pine Point Mines.

Ballast

Known sources of gravel suitable for the production of ballast are scarce and spaced far between in the vicinity of the new railway route. Aerial photographs covering a distance of six miles on each side of the right-of-way were studied for indications of gravel and sand deposits. This was followed with prospecting and testing on the ground.

To date only three deposits of importance have been discovered: (1) at Mile 10, (2) at Mile 225, and (3) at Mile 34 on the branch to Pine Point. It is necessary to crush, screen and wash some of the pit run materials in order to obtain a product suitable for ballast.

The quantity required may amount to 2,000,000 cu yd, with train hauls up to 150 miles. Ballast is distributed for the first and second lifts and for final line and surface. After being loaded, hauled and distributed, the ballast for the first and second lifts is placed under the ties by using a sled pulled by a locomotive. Very little labor is necessary for this procedure. Mechanical jacks, tamping, lining and regulating machines are used for final lift and surface.

Two 50-man gangs housed in on-track bunk and boarding cars are employed; they are followed by one 15-man gang which erects right-of-way fences, track signs, etc. Other gangs maintain the track in the rear.

Communications

No telegraph or telephone line has been erected on the right-of-way. All train dispatching and communications between stations and the head-end and rear-end of trains is done by radio connection with an overall micro-wave system.

CONSTRUCTION PROGRESS

By December 1963, the following work had been carried out:

Clearing right-of-way was completed from Roma to Hay River and on the branch line easterly for 34 miles to the Buffalo River. Grading and installation of culverts had been completed to Mile 245, except some trimming, and two contractors were working on sections northerly toward Hay River and also easterly to Pine Point. Grading was carried out with the common types of equipment—draglines, self-propelled scrapers on rubber, scrapers with tractors, compactors and graders.

Bridges had been completed up to Mile 234. Contracts were awarded and work was underway on the balance of the structures. Track was laid to Mile 225 and was scheduled to proceed northward. The year 1963 was critical because it was desired to reach gravel deposits at Meander, Mile 225.

The first lift of ballast was placed to Mile 153; the second lift followed closely. Materials were hauled from Mile 10 until a stockpile of pit-run gravel at Mile 125 was reached. The first gravel was hauled by truck a distance of 20 miles from the east of the right-of-way, during the winter of 1962–63, to provide some material for the first lift until material became available from Meander in the spring of 1964.

As of July 1964, 290 miles of main track have been completed, almost to the north boundary of the Province of Alberta, and about to enter the Northwest Territories.

TRAFFIC UNDER CONSTRUCTION

Fifty miles north of Peace River town, the business community of Manning was established on the Notikewin River to serve a territory of some 1000 square miles of rich farm lands. The Great Slave Lake Railway passes close by Manning. During the summer of 1962 four grain elevators were built at this siding in readiness for marketing the annual crop.

Track was laid to Manning in October 1962. There were immediate requests for empty box cars to be spotted at the elevators for loading grain to be hauled to the seaboard at Vancouver for export. To date 882 carloads of grain and 308 cars of lumber, etc., have been shipped outward. There has also been inward traffic of equipment and building materials.

Now that the railhead has been advanced through the districts of Keg River, Paddle Prairie and High Level to Meander, Mile 225, agricultural and forest products will be shipped from as far north as High Level, Mile 180, and Fort Vermilion, 45 miles to the east. Considerable inward traffic—building materials, equipment and fuels—is expected at High Level and Meander, for transshipment to Pine Point Mines, townsite, mill, concentrator, etc.

By the winter of 1964–65 the track will be at Enterprise, Mile 350, where it is expected that a station will be built for transferring freight from rail to highway movement by road around the west end of Great Slave Lake to the gold mining town of Yellowknife.

Each winter bridge materials, ties, rails and fastenings for the following year are transported by work train to the advance railhead.

Even this initial rail service to Manning, Hotchkiss, Keg River and High Level has resulted in appreciable benefits to grain growers and lumbermen in this territory, and the new railway is stimulating further development. From Roma, Mile 0, 300 miles of the line run through Alberta to the northern boundary, latitude 60 deg, where the Northwest Territories are entered. Hay River, latitude 61 deg, will be the most northerly railway terminal connected directly to the main continental systems to the south.

CLIMATE

Around Peace River and northerly for 180 miles through Manning, Hawk Hills, Keg River and High Level, the climate is similar to other agricultural areas of the western prairies. All normal crops—wheat, oats, barley, rye, flax seed and rape seed—are grown successfully. The number of frost-free days is somewhat less than in central Alberta, but this is compensated for by the longer summer daylight period in Northern Alberta.

A Government experimental station has been operated at Fort Vermilion, in the North Peace Valley, latitude 58 deg 23 min, for many years. The duration of the vegetative period (mean temperature at or above 42 F) is 143 days—May 5 to September 15. The length of daylight in this period is 2340 hr. Winter temperatures at times drop to

50 F below zero. Normally the earth is frozen, and snow 2 to 3 ft deep is on the ground from the end of October to mid-April. Yearly precipitation amounts to 12.1 in.

Summer temperatures range up to 80 F. Rainfall amounts to 8.8 in. At the summit, between the watershed tributary to the Peace River and streams flowing to Hay River and northerly to Great Slave Lake, the influence of the sub-arctic is felt. However, good garden crops of vegetables and small fruits may be grown near Hay River in the Northwest Territories, latitude 61 deg, and summer temperatures are pleasant, at times up to 80 F. During mid-summer the days have little darkness.

The winters are longer than in the south, commencing in October and extending through April. Temperatures at times drop to 60 F below zero, but for short periods only. The depth of snow varies from 2 to 4 ft. At Yellowknife, latitude 62 deg, the average summer temperature during June, July and August is 57 F, and during winter, November to March, incl, the average daily temperature is 8 F below zero.

ACKNOWLEDGEMENTS

The author extends thanks to V. R. Cox, engineer of location and construction, and F. L. Peckover, engineer of soils and foundations, both of the Canadian National system headquarters staff, Montreal, Que.; also, R. C. Thurber and Associates, specialists in soils engineering, Victoria, B. C., for their liberal assistance.

Aerial photography was done by Hunting Corporation, Toronto, Ont. Photogrammetric mapping was done by Canadian Aero Service Limited, Ottawa, Ont., and McElhanney, McRae, Smith and Nash, Vancouver, B. C.

Dr. Mollard & Associates, Regina, Sask., made the photo analysis to assist in prospecting for ballast materials.

CONCLUSION

The North has great potentials and presents a great challenge to develop them. The Great Slave Lake Railway will do much toward realizing the area's potentials.

Advance Report of Committee 16—Economics of Railway Location and Operation

Report on Assignment 7

George S. Sowers (chairman, subcommittee), G. G. Alison, G. A. Bennewitz, Jr., W. G. Byers, C. P. Chitwood, H. B. Christianson, W. J. Dixon, H. J. Kay, F. A. Koomanoff, T. C. Nordquist, J. F. Partridge, J. J. Stark, Jr., L. E. Ward, P. B. Wilson.

An Industrial Engineering Study of a Freight Car Repair Facility*

By GEORGE S. SOWERS

Assistant Director—Industrial Engineering
Missouri Pacific Railroad

INTRODUCTION

The Missouri Pacific has a freight-car repair and manufacturing plant at DeSoto, Mo, which is a production facility for satisfying car demands. An industrial engineering study was conducted in May 1962, looking to improving production and reducing costs. This report outlines the fundamental methods employed in the study.

1. Determine Objective and Scope of Study

The study was made to determine the extent to which production could be improved and costs reduced by application of generally accepted industrial engineering techniques. The basic groundwork performed during the early stages of the study indicated that three distinct phases of work might be undertaken. These were logical steps toward the ultimate upgrading of the operation, each utilizing the improvements developed in the preceding phase. These steps were:

Phase I—Make changes in methods and minor changes in equipment without making significant revisions to the layout or flow process.
Phase II—Make changes in methods and minor changes in equipment and streamline the flow by relocating major functional activities.
Phase III—Relocate and expand support functions, introduce new heavy equipment, and provide car-manufacturing facilities based on modified construction techniques.

Preliminary examination of the three phases indicated that maximum benefit would be realized by combining Phases I and II. Consequently, the scope of the study was limited to a methods-and-layout analysis.

The following assumptions were made:

1. The facility would continue as the system's major freight-car repair point.
2. The quantity and mix of cars would remain essentially the same as those presently in effect.
3. There would be no change in basic car design.
4. The quality and extent of car repairs would not be materially changed.

---

* A condensation of a 56-page, detailed report. A limited supply of the original report is available. Requests for copies should be addressed to the author at St. Louis, Mo. 63103.

2. Approach to the Study

Our approach to the study consisted of the following steps:

1. Gather detailed information and data concerning the facility.
2. Discuss freight-car repair policies and practices with supervisory personnel.
3. Visit representative facilities of other companies.
4. Secure and review pertinent data relative to:
   a. the freight car catalog,
   b. the previous year's repair programs,
   c. cost data for car repairs.
5. Develop and prepare physical data relative to:
   a. the layout and utilization of yard, buildings, equipment and utilities,
   b. the work flow.
6. Develop and prepare organization charts and labor assignments.
7. Conduct a work sampling of the labor performance.
8. Develop a work-station analysis of line, support and supply operations for the gondola general-repair program.
9. Prepare flow and manning charts for the three major types of freight cars—gondola, hopper and box.
10. Contact suppliers.
11. Analyze the facts and opinions developed and weigh the numerous possible alternatives for product flow, layout and methods improvements.

3. Description of Present Operation

Production operations are the responsibility of 12 supervisors supported by 3 staff positions. Employees reporting to the supervisors, based on the manning for gondola car repairs during the May-through-July study period, were:

Direct line labor	157
Production support labor	62
Other support labor	71
Total	290

The property is approximately 3800 ft long and 800 ft wide, and is adjacent to the main line; 235,300 sq ft of the area are under roof in 23 different buildings situated primarily in the south central portion of the plot. (The approximate ratio of covered floor area to ground area is 1/13 which was considered sufficient for an operation of this type.)

The fabricating shop is the only modern building. However, the floor area in this building for support functions is restricted, especially at the north end of the shop where most of the machine tool equipment is concentrated. This condition causes some work interference, numerous material handlings, and excess demand for the two 10-ton overhead bridge cranes. The aisles are inadequate for mobile handlings, and there is insufficient in-process component storage area.

Many of the other structures are old and require heavy maintenance. Their physical features are characterized by poor lighting, restrictive column centers, and inadequate structural capabilities for supporting overhead mechanized handling systems.

Some operations, such as stripping, sandblasting, underframe painting, final painting and stenciling, are conducted outside, and work delays are frequent during periods of inclement weather. As a consequence, additional storage tracks and float positions are required to provide a steady flow of cars. This creates overmanning and idle time, and contributes to an out-of-balance condition.

In spite of the over-age buildings and extensive supporting property, housekeeping and general appearance are at a very high level. In the context of the short-range cost study, the facility was considered to be generally adequate.

The track layout, comprising approximately 7 miles, does not permit easy passage of convoy cars between the north and south ends of the facility. Consequently, much material is rehandled from isolated storage to use points by fork lift trucks and straddle carriers in relatively small unit loads.

The facility is well covered with a network of hard-surfaced roads. The concrete roadways are adequate to move equipment and materials between operations without excessive travel. Fig. 1 shows the present facility and the work-station layout.

The facility performs general repairs for the entire freight car complement on the system. A car is considered to have undergone a "general repair" if the repairs cost more than $500 or required more than 100 man-hours to complete. The types of work in a general repair program include the following:

1. Overhauling and replacing trucks or components.
2. Major repairs or replacement of car underframes, bolsters, crossties and draft gear.
3. Straightening and squaring car frames and bodies.
4. Repairing structural failures.
5. Replacement of side sheets, bottom sheets and roof sheets.
6. Rebuilding doors.
7. Major modifications concerned with upgrading and rebuilding cars for specific purposes.
8. Repainting cars.

During the five-year period 1957–1961, the shop built 5900 new cars and repaired 5800 cars, an annual average of almost 1200 cars in each category.

Cars in a series designated to undergo general repair are ordered into the shop from the entire system. These cars are collected on storage tracks adjacent to the main line north of the property. Cars are delivered daily to the repair yard by a switch engine.

Incoming cars are moved into the feed track at the south end of the property leading to a repair track. The strip-track supervisor inspects cars at this location and notes any conditions which would necessitate unusual work during the repair operations. From this point, cars are moved individually (or in convenient work groups) through all of the subsequent work positions, each car moving about 2.4 miles for the total cycle. Transfers between positions are made by winch or light-duty industrial tractors. There are 14 work areas for a gondola-car repair cycle, varying in number of work positions from one for inspection to 27 for erection.

After the stenciling operation the completed cars are moved from the facility by the same switch engine that delivered the car to the facility initially; this move completes the work cycle.

The 12-month period ending April 30, 1962, was selected for a detailed examination of the operating cost. The purpose of the investigating was to develop an actual total cost of operation, to identify high-cost centers, and to determine unit costs. This would permit specific evaluation of savings and further reveal the cost spread encountered in individual car repairs in a series and in a program.

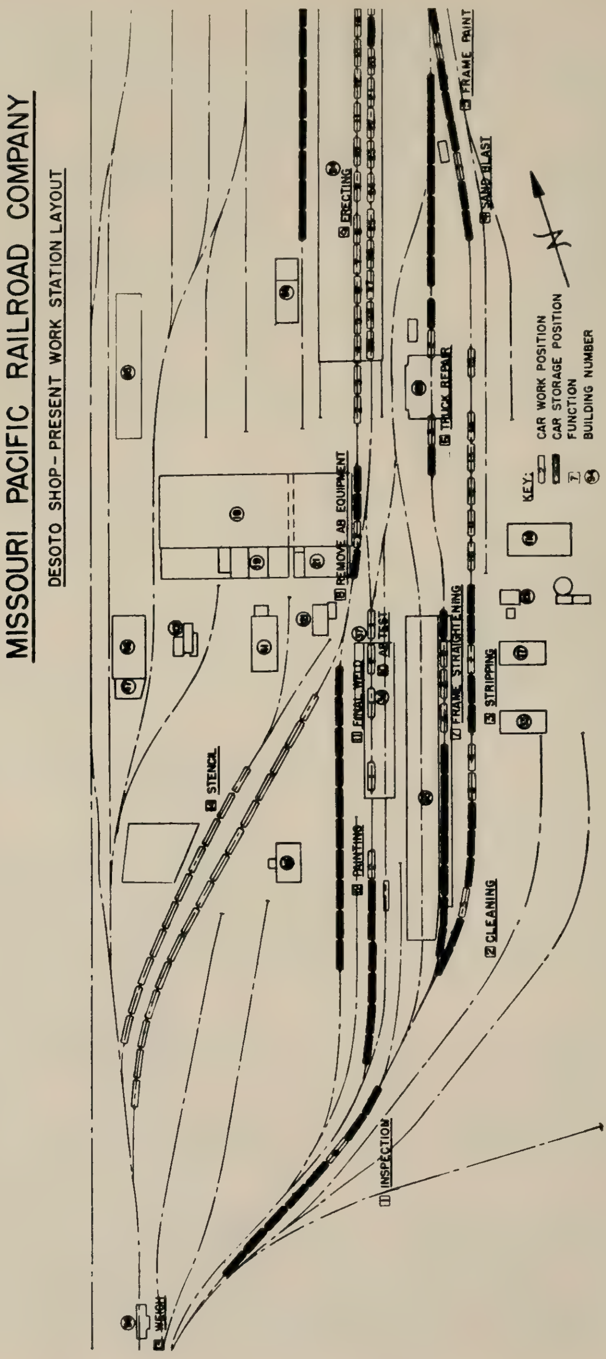

MISSOURI PACIFIC RAILROAD COMPANY
DESOTO SHOP- PRESENT WORK STATION LAYOUT
1 INSPECTION
2 CLEANING
3 STRIPPING
4 FRAME STRAIGHTENING
5 TRUCK REPAIR
6 SAND BLAST
7 FRAME PAINT
8 ERECTING
9 REMOVE AB EQUIPMENT
10 AB TEST
11 FINAL WELD
12 PAINTING
13 STENCIL
14 WEIGH
N
KEY:
CAR WORK POSITION
CAR STORAGE POSITION
FUNCTION
BUILDING NUMBER

Fig. 1.

During the 12-month analysis period, 1733 freight car underwent general repairs and 142 new cars were built. The total cost to produce this mix of repaired and new freight cars was $3,831,000.

4. Data Collection and Analysis

In order to become acquainted with the details of layout, flow, work stations and manning, a number of separate studies were conducted. The first of these was a work-sampling study of all hourly personnel. Work sampling is a statistical technique in which the busy-idle cycle of the worker is determined.

The study was conducted by dividing the facility into natural work areas, each covered by an observer. Five such areas were established, within which subdivisions were made to include logical work teams of labor. The study indicated a productive range of from 45 to 100 percent for various individuals or crews. Of the 10,500 observations made in the three-day sampling period, approximately 72 to 77 percent were made when the worker was involved in productive activity (see Fig. 2).

Forms were developed for collecting data. The Station Analysis Form (Fig. 2) was developed to gather detailed data as to the equipment used, manning required, operations performed and approximate time to perform various segments of the operations. A layout sketch was drawn for each work station. These studies concentrated primarily on the work stations set up for gondola-car repair (Fig. 3 was prepared from data collected during these operations as presently organized).

The Flow Process Charts summarized the manning and operations performed at each work station and storage positions, and during car movements. These charts were reviewed with the supervisors to verify their accuracy.

Data collection is based on these five basic questions:

1. What is the function?
2. Where is the function performed?
3. When is it performed?
4. Who performs the function?
5. How is the function performed?

Analysis of the data is based on the sixth and most important question, "why?" The "why" question is asked of each of the five basic questions:

1. Why is the function being performed?
2. Why is it being performed where it is?
3. Why does it have to be performed at this time?
4. Why does man (group) "A" have to do it?
5. Why is it being performed this way?

Our analysis found that the serpentine flow pattern—created by the multiple production lines—was the big factor in the total length of the production line (2.4 miles). There were these five separate production lines:

1. Inspection, cleaning, stripping, sandblasting and frame painting.
2. Truck repair and frame straightening.
3. AB-equipment removal and inbound erection.
4. Outbound erection, AB test, final welding and painting.
5. Weighing and stenciling.

SUMMARY OF WORK SAMPLING STUDY

	First Day	Second Day	Third Day	Total
Productive	2,971	4,156	1,818	8,945
Nonproductive	885	1,136	609	2,630
Unavailable	358	321	172	851
Per Cent Productive (Excluding Unavailable)	77.1%	78.5%	74.9%	77.3%
Per Cent Productive (Of Total)	70.5%	74.0%	69.9%	72.0%
Per Cent Productive (Assuming Unavoidable is Productive)	79.0%	79.8%	76.8%	78.8%
Number of Men Studied	303	309	288	300 (Ave.)

STATION ANALYSIS FORM

Major Function: ______________________ Date: ____________

Station No.: ____________ Total Manning: ______ Program: ________

Description ____

Equipment ____

Observer ________________ Remarks ____________________

ANALYSIS OF OPERATIONS

No.	Worker	Equipment	Description	Approx. Time

Sketch layout on back of sheet.

Fig. 2.

We also found certain work areas where the excessive time required to perform the work resulted in storage and work imbalance. The major work areas involved were stripping, sandblasting, truck repair, portions of the erection cycle and painting. The main reasons for the abnormal time requirements were the non-alternative production path and manning imbalance.

On-line component fabrication in the erection cycle contributed to both delay and congestion. Congestion in this high-activity work area created a safety problem—although well controlled—that could get out of hand with any significant increase in production.

Some of the operations were being performed out-of-doors, which not only contributed to production delay during inclement weather, but also—as in the case of paint-

GONDOLA REPAIR

Partial Cycle Comparison

Present				Proposed	
Operation & Station No.	Manning	Description of Operation		Operation & Station No.	Manning
		Move cars into yard with switch engine			
Inspection				Inspection	
▽		Storage		▽	
○	1	Inspect		○	
▽		Storage		▽	
⇩		Move 2 cars with tractors	Move 4 cars with 1 trackmobile	⇩	
Cleaning				Cleaning	
▽1		Storage	Clean residue from car	①	1
▽2		Storage	Move with winch	⇩	
				Stripping	
③	1	Clean residue from car	Burn off rivets, remove safety appl.	①	3
▽4		Storage	Knock out rivets, remove side posts	②	2
⇩		Move with winch	Remove sides	③	1
Stripping					
▽1		Storage	Cut floor plates	④	2
▽2		Storage	Burn off end rivets, remove top chord	⑤	1
③	4	Burn off rivets, remove safety appl.	Knock out remaining rivets	⑥	½
④	1	remove side posts	Remove ends, floor, plates and crossties, as required	⑦	2-½
▽5		Storage	Storage	▽8	
▽6		Storage	Move with trackmobile	⇩	
⑦	2	Knock out rivets	End of cycle		
▽8		Storage			
▽9		Storage			
⑩	3	Remove sides			
⑪	2	Cut floor plates			
⑫	1	Burn off end rivets, remove top chord			
⑬	½	Knock out remaining rivets			
⑭	5-½	Remove ends, floor plates and crossties, as required			
▽15		Storage			
⇩		Move cars with tractor			
		End of Cycle			

SUMMARY

Description	Present	Proposed	Savings
Operation	10	9	1
Move	4	4	-
Delay (Storage)	12	3	9
Manning	21	13	8

Fig. 3.

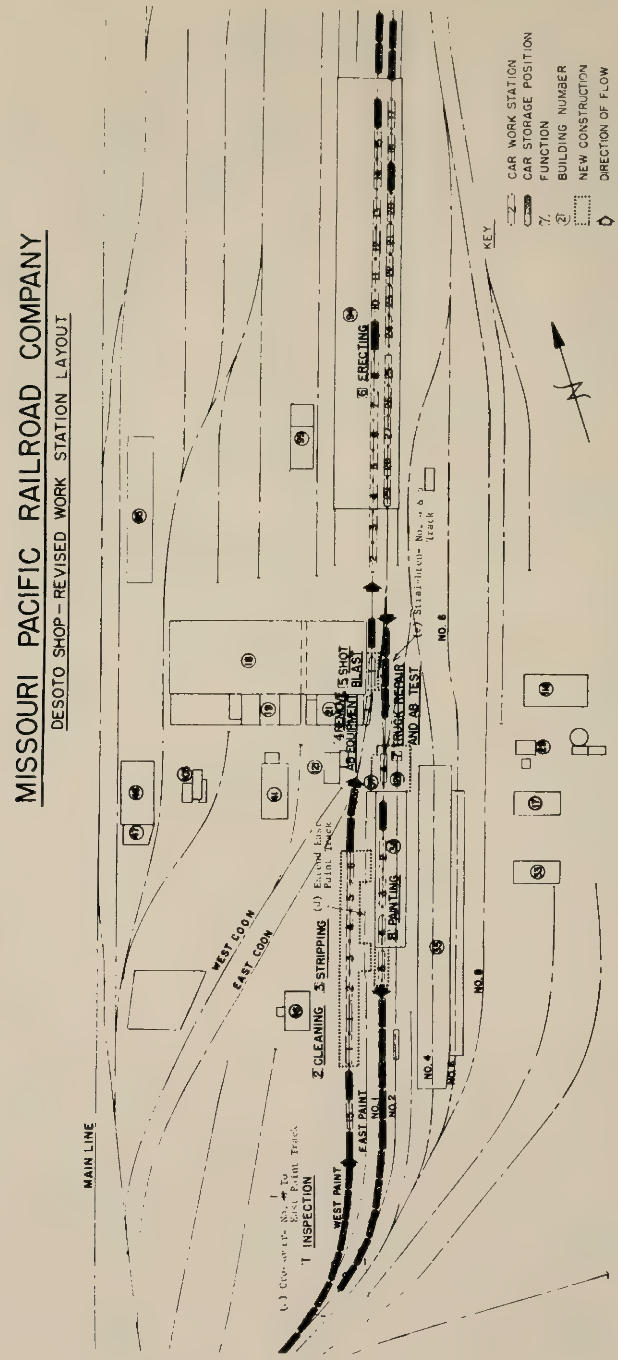

MISSOURI PACIFIC RAILROAD COMPANY
DESOTO SHOP - REVISED WORK STATION LAYOUT
KEY
CAR WORK STATION
CAR STORAGE POSITION
FUNCTION
BUILDING NUMBER
NEW CONSTRUCTION
DIRECTION OF FLOW
N
MAIN LINE
WEST COON
EAST COON
1 INSPECTION
2 CLEANING
3 STRIPPING
4 REMOVE AB EQUIPMENT
5 SHOT BLAST
6 ERECTING
7 TRUCK REPAIR AND AB TEST
8 PAINTING
WEST PAINT
EAST PAINT
NO.1
NO.2
NO.4
NO.6
NO.8
(c) Crossover No. 1 To East Paint Track
(d) Extend East Paint Track
(e) Straighten No. 6 & 7 Track

Fig. 4.

ing—resulted in a poor product. Damage claims from nearby residents were another costly by-product ("windy painting").

Multiple hoisting of cars—particularly in the truck-repair cycle—caused delay, over-manning and excessive storage requirements. Positioning this work station after frame painting also contributed to poor work methods.

Shop equipment, both on- and off-line, caused delay, over-manning and excessive material requirements. Age of the equipment and work methods were the big factors contributing to these cost items.

Extensive use of rivets in the erection cycle caused delay and minor safety and supervision problems. Riveting noise in the erection shop contributed to man fatigue and poor performance; oral communication in this area was also difficult because of the noise.

5. Develop Proposed Operation

In developing the revised operation, the major aims were as follows:

1. Reduce car movement (target, one mile).
2. Balance the production line.
3. Reduce, or eliminate, on-line component fabrication.
4. House all operations.
5. Avoid lifting cars.
6. Improve shop equipment.
7. Replace rivets with pull fasteners.

Proposed Flow Process Charts and a detailed write-up of the proposed operation, incorporating the above revisions (where economically feasible), were prepared, showing the reduced number of operations, moves and delays that would result. (Figs. 3 and 4 show the proposed operation).

6. Summarize Costs and Savings of Proposals

Those areas involving changes in methods, equipment, housing, etc., were analyzed to determine the cost of such changes. Some changes, such as in car movements and lifting of cars, had small cost requirements. Others, such as housing, would cost almost $300,000.

Finally, the improvements in production and manpower utilization were evaluated to determine if sufficient savings could be realized to offset the cost of the changes. Our estimate of the annual savings amounted to $316,000.

CONCLUSION

As indicated in the section headings in this paper, the study consisted of the following basic steps:

1. Determine the objective and scope of the study.
2. Decide which approach should be used for the study.
3. Prepare a factual account of the present operation.
4. Collect necessary data and prepare exhibits.
5. Develop a proposed operation that will improve production and reduce costs.
6. Summarize costs and savings of proposed operation to determine economic feasibility of the proposals.

Epoxy Resin Coatings on Steel and Concrete*

A. FIELD INVESTIGATION OF EPOXY RESIN COATINGS ON STEEL AFTER TWO YEARS OF EXPOSURE

1. Foreword

The advance report of Committee 7—Wood Bridges and Trestles, which appears in AREA Proceedings, Vol. 64, describes several epoxy resin formulations that might be used to coat steel as protection against brine, including two two-coat systems specifically recommended for this purpose. The following report describes a service test of the two-coat systems along with several other coatings to provide comparative data, applied to steel test plates.

The deck of the Huey Long Bridge, New Orleans, La., was selected as the test site because of the temperate climate and high humidity of the region and the heavy concentration of brine from refrigerator cars to which the bridge is subjected. The AAR provided the laboratory facilities and personnel as part of the research activity of the AAR Research Department, of which W. M. Keller is vice-president and G. M. Magee is director of engineering research. The conduct of the investigation, analysis of data and preparation of this report were under the general direction of F. P. Drew, research engineer structures, assisted by D. W. Wilki, chief draftsman, I. A. Eaton, laboratory engineer and R. Trubic, laboratory assistant. E. F. Garland, bridge supervisor, New Orleans Public Belt Railroad, maintained the specimens on the bridge. This report was written by Mr. Drew.

2. Description of Coatings

The formulations applied to the test plates are described in detail in the aforementioned advance report of Committee 7, pages 8 to 15, incl., of the Proceedings, Vol. 64.

The following systems were used:

One coat of formulation P1

One coat of formulation C1

These are both 100-percent-solids systems. The epoxy resin is of low molecular weight cured with a moderately reactive modified aliphatic amine.

A two-coat system consisting of a primer coat of formulation 285–1 and a second coat of formulation 285–6

A two-coat system consisting of a primer coat of formulation 285–22 and a second coat of formulation 632–1255

These are both solvent systems. The epoxy resin is of high molecular weight, 60 percent solids, cured with an aliphatic polyamine.

One coat of tar-filled epoxy resin.

This is a proprietary system for which the formulation is not known.

One coat of formulation 242–2

This is a solvent system. The epoxy resin is of a low molecular weight, 90 percent solids, cured with an aliphatic polyamine and extended with tar.

---

* This report is sponsored jointly by Committee 7—Wood Bridges and Trestles, Committee 8—Masonry, and Committee 15—Iron and Steel Structures.

Photograph 1—Coated test plates on Huey Long Bridge.

TABLE 1. WEIGHT OF COATINGS

Type of Coating	Mark	Plate lbs	Plate & Coating lbs	Coating lbs	Type of Coating	Mark	Plate lbs	Plate & Coating lbs	Coating lbs
P1	101	9.68	9.76	.08	Proprietary Tar Coating	125	9.67	9.77	.10
	102	9.89	9.95	.06		126	9.88	9.93	.05
	103	9.77	9.83	.06		127	9.79	9.85	.06
	104	9.88	9.94	.06		128	9.87	9.95	.08
	105	9.79	9.85	.06		129	9.82	9.88	.06
	106	9.80	9.87	.07		130	9.77	9.84	.07
C1	107	9.83	9.90	.07	242-2	131	9.96	10.11	.15
	108	9.75	9.82	.07		132	9.89	9.98	.09
	109	9.75	9.82	.07		133	9.63	9.70	.07
	110	9.88	9.94	.06		134	9.80	9.88	.08
	111	9.54	9.61	.07		135	9.88	9.95	.07
	112	9.85	9.92	.07		136	9.71	9.81	.10
285-1	113	9.93	9.98	.05	Uncoated	137	9.98	-	
	114	9.84	9.91	.07		138	9.84	-	
	115	9.92	9.99	.07		139	9.91	-	
285-6	116	9.91	9.96	.05		140	9.92	-	
	117	9.76	9.81	.05		141	9.90	-	
	118	9.57	9.62	.05		142	9.89	-	
285-22	119	9.90	9.91	.01					
	120	9.81	9.83	.02					
	121	9.85	9.88	.03					
632-1255	122	9.80	9.83	.03					
	123	9.80	9.83	.03					
	124	9.71	9.72	.01					

3. Test Specimens

The plates were of A 7 steel, 7 by 10 in, ½ in thick. Each had two 9/16-in holes for fastening to the bridge deck. An identifying number was stamped on the surface of each plate near one corner and edge burrs were filed off. Immediately prior to the coating application, the plates were sandblasted to "white" metal.

Six plates were coated, each with a different system, and six were left uncoated. The uncoated plates were not sandblasted.

All formulations were proportioned by weight and hand mixed with wooden paddles. All were applied with a brush. The weight of each applied coating was determined by weighing the plates before and after coating. These are shown in Table 1. The thickness of each coating was measured with an elcometer (thickness gage) at several points on the surface, as indicated in Table 2.

Coatings P1, C1, and the proprietary tar coating were applied immediately after mixing. The others were allowed to age in the mixing container for 1 hr before application. For the two-coat systems, the first coat was permitted to harden for 24 hr before applying the second coat. These procedures were recommended by the manufacturers.

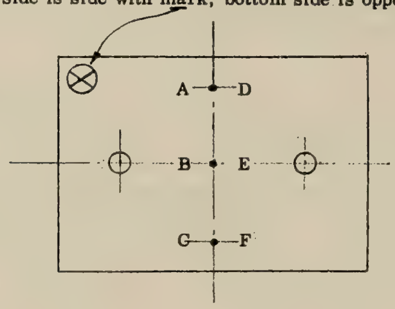
After application, the coatings were allowed to cure at room temperature, each plate resting on three nail points. After the coating had hardened, the nail-point holes were touched up with additional coating material. The C1 coating required curing for more than 24 hr at room temperature before it was hard enough to handle.

It was thought that the converters for P1 and C1 were interchanged, but the resin manufacturer felt that this would not have a measurable influence on the performance

TABLE 2. THICKNESS OF COATINGS

Type of Coating	Mark	Top Side A	B	C	Bottom Side D	E	F	Type of Coating	Mark	Top Side A	B	C	Bottom Side D	E	F
P1	101	11	12	11	20	20	17	285-22 632-1255	119	4	4	3	4	5	5
	102	11	13	11	16	13	13		120	3	3	3	5	6	5
	103	4	6	6	20	20	17		121	3	2	3	4	4	5
	104	6	6	11	16	16	12		122	4	3	4	6	6	6
	105	12	7	15	18	12	14		123	2	2	2	4	3	4
	106	11	6	9	14	15	19		124	4	4	3	4	6	6
C1	107	13	15	10	20	14	20	Proprietary Tar Coating	125	10	14	16	10	10	6
	108	10	10	10	13	20	13		126	11	7	7	6	6	12
	109	18	10	10	13	19	20		127	11	8	8	4	8	8
	110	14	12	10	21	16	19		128	11	10	10	10	9	9
	111	16	20	20	20	20	20		129	10	11	11	9	8	14
	112	12	12	15	20	13	13		130	8	8	10	14	19	20
285-1 285-6	113	3	3	4	12	12	10	242-2	131	10	12	11	8	8	5
	114	4	4	4	8	8	9		132	10	7	10	7	9	8
	115	4	3	3	8	11	7		133	4	4	5	10	11	10
	116	4	4	4	11	11	10		134	11	6	5	11	6	6
	117	5	4	4	10	10	11		135	7	7	7	5	8	8
	118	4	3	4	9	9	9		136	7	10	14	7	7	10

Thicknesses shown are in mils
Top side is side with mark, bottom side is opposite.



of the coatings, as both coatings were hard and apparently well cured when exposure began.

The 242-2 coating was still tacky after 16 hr of curing at room temperature. Since the other plates were all ready to be shipped, it was necessary to accelerate the curing rate of that coating, so it was placed in an oven at 140 F, for 4 hr. The coating then became hard.

The manufacturer's specification for the thickness of the proprietary tar coating was 10 mils. To attain this thickness it was necessary to apply a second coat to some surfaces. Even so, in some cases the final thickness was not the specified 10 mils, but further coating was not considered practical.

Each coated plate was wrapped in paper, packed in fiberboard boxes and shipped to the site at New Orleans. They were fastened to the spacer timber on the bridge with lag screws, as shown in Photograph 1, at the following locations:

Set A near bent 160W; Plates 101, 107, 113, 119, 125, 131, 137.
Set B near bent 154W; Plates 102, 108, 114, 120, 126, 132, 138.
Set C near bent 152W; Plates 103, 109, 115, 121, 127, 133, 139.
Set D near bent 148W; Plates 104, 110, 116, 122, 128, 134, 140.
Set E also near bent 148W; Plates 105, 111, 117, 123, 129, 135.
Set F near bent 146W; Plates 106, 112, 118, 124, 130, 136.

The plates of each set were arranged with the low-numbered plates toward the east end of the bridge. Sets A, B, C, D and E are on a 4-deg curve, set F is on tangent.

4. Test Results

The plates were placed on the bridge on January 10, 1962. Two inspections have been made since then, one on September 25, 1962; the other on December 27, 1963. The following observations were made:

Plate	*1962 Inspection*	*1963 Inspection*
	COATING P1	
101	Some scaling around edges, no rusting on surface.	Edges rusted and peeling, blisters around lag screws.
102	Badly blistered all over, particularly near lag screws.	Coating nearly all gone, edges rusted, large blisters and scaling.
103	Edges blistered all around, blisters around lag screws.	Coating on surface and edges nearly all gone.
104	Edges badly blistered, large area of blisters around lag screws.	Blisters all over surface, edges exposed and rusted.
105	Edges scaled, surface around lag screws blistered.	Badly scaled and blistered all over.
106	Edges blistered all around, also around lag screws.	Blisters all over, edges exposed and rusted.
	COATING C1	
107	Blisters around lag screws and coating off on one edge.	Edges rusted and peeling, blisters around lag screws.
108	Downhill edge spalled off, has cut in surface.	Coating nearly all gone, edges rusted, large blisters and scaling.
109	Some large blisters, particularly near downhill lag screw; edges rusting.	Coating on surface and edges nearly all gone.
110	Downhill edges blistered, blisters around lag screws.	Badly blistered all over, edge coating gone.
111	Coating on downhill edge all gone, blistering around lag screws.	Badly scaled and blistered all over.
112	One edge scaled, blisters around lag screws.	Edges all exposed, blisters all over.
	COATING 285–1, 285–6	
113	Some blistering, but not broken through.	Large blisters around lag screws, small blisters on downhill edge and few small blisters elsewhere on surface.
114	A few small blisters, worse at downhill lag screw.	Large blister near downhill lag screw, few other small blisters.
115	A few small pin holes of rust, cut in surface is rusting.	Large blisters around lag screws, otherwise OK.

Plate	*1962 Inspection*	*1963 Inspection*
116	One small blister near uphill lag screw.	Few small blisters, mostly around lag screws, edges OK.
117	Some blisters around lag screws.	Large blisters around lag screws, otherwise OK.
118	A few small blisters near lag screws.	Large blisters around lag screws, some on field edge, too.
	COATINGS 285–22, 632–1255	
119	No rust or blisters.	Few small blisters around lag screws, otherwise looks very good.
120	Only one small blister near downhill lag screw.	Few small blisters around lag screws, small blisters on field and uphill surfaces, surface in general looks very good.
121	Some rusting near downhill lag screw.	Some blisters near lag screws, otherwise OK.
122	No rust or blisters.	Very small blisters around lag screws, surface looks very good.
123	No rust or blisters.	Few small blisters around lag screws, downhill edge slightly scaled.
124	No rust or blisters.	Few small blisters around lag screws, otherwise surface looks very good.
	PROPRIETARY TAR-FILLED COATING	
125	Badly blistered near lag screws and also some small rust areas.	Blistered around lag screws and at downhill edge, edge peeling.
126	Some large blisters.	Edges peeled off and badly rusted, large blisters on surface near downhill edge around lag screws and near field edge.
127	Rust and blisters around lag screws.	Blisters around lag screws, downhill edge is gone, blisters near gage edge.
128	Some blisters around lag screws.	Large blisters around lag screws and on surfaces near downhill edge and field edge.
129	Badly blistered around lag screws, uphill edge spalling.	Large blisters around lag screws and between lag screws and uphill and downhill edge.
130	Only one small spot of rust.	Blisters around bolts, coating broken at all edges.
	COATING 242–2	
131	Very small amount of pin hole rusting.	Blistered around lag screws, edges badly rusted and peeling.
132	Some small blisters at downhill corner and around lag screws.	Large blisters on surface near downhill edge, track side edge OK, others badly rusted and peeling.
133	Small amount of rust on downhill edge.	Blisters around lag screws and on surface near downhill and track side edges, downhill edge coating gone.
134	Some blisters around lag screws.	Many blisters around lag screws, surface near downhill edge and field side also blistered.
135	Blisters around lag screws.	Many blisters around lag screws, surface near uphill and downhill edges blistered, edges scaling.
136	Blisters around uphill lag screw, rust on one corner.	Badly blistered around lag screws, edges scaled.

From the appearances of these coatings after nearly two years of exposure, it is apparent that the two-coat systems are more resistant to a briny environment than any of the one-coat systems used. Of the two two-coat systems tested, the 285–22, 632–1255 combination appears to be the best. This is also the thinnest of all the coatings. The tar-filled coatings are offering better resistance than either the P1 or C1 coatings, but do not appear to be particularly effective in this environment. As indicated under the 1962 inspection results, most of the blistering originated near the lag screws, and there may have been surface abrasion at this point to cause local coating failure. The blisters appear to have grown and radiated out from the lag screws during the second year of exposure. Also during this period, and particularly with coatings P1, C1 and the tar-filled coatings, blisters formed at other places as well. While the 285–22, 632–1255 coating is blistered around the lag screws, the rest of the exposed surface is comparatively free of blisters, rust or scale, and the coating appears to be offering good protection. This is the coating that is recommended for corrosion protection.

5. Acknowledgments

The coating materials were furnished by The Clinton Company, The Dearborn Chemical Company, and the Jones–Dabney Company.

B. LABORATORY INVESTIGATION OF EPOXY RESIN WATERPROOFING COATINGS ON CONCRETE

1. Foreword

Reports of Committee 7—Wood Bridges and Trestles, in the AREA Proceedings, Vols. 62 and 64, describe various epoxy resin formulations that might be used for waterproofing concrete surfaces, recommending particularly formulations 632–1255 and 632–1555. The following report discusses an investigation of the performance of these coatings and others that might also be used. The investigation was conducted at the AAR Research Center in accordance with the acceptance tests for coatings set forth in "Specifications for Waterproofing Coatings for Exposed Concrete Surfaces," AREA Manual, pages 29–4–1 to 29–4–5, incl.

The conduct of the investigation, analysis of data and preparation of this report were under the general direction of F. P. Drew, research engineer structures, assisted by R. Byrne, chemical engineer, D. W. Wilki, chief draftsman and W. H. Hillis, Jr., test assistant. This report was written by Mr. Drew.

2. Description of Coatings

The coating formulations tested are described in detail in the Proceedings' references given above. The following systems were applied to concrete test specimens:

- One coat of formulation P2
- Two coats of formulation P2
- A two-coat system consisting of a first coat of formulation P2 and a second coat of formulation C1
- Two coats of formulation C1
- One coat of formulation P1
- Two coats of formulation P1 (flexibilized)

The above formulations are all 100-percent-solids systems. The epoxy resin is of low molecular weight cured with a moderately reactive aliphatic amine. The P1 (flexibilized) coating was mixed with the components shown for formulation P1 except that the converter portion was increased from 50 to 81 parts-per-100-resin, which is the equivalent of equal parts of resin and converter by volume.

Two coats of formulation 632–1255
One coat of formulation 632–1555
One coat of formulation 632–1895

These are all solvent systems. The epoxy resin is of high molecular weight, 60 percent solids cured with a polymeric amidoamine. The 632–1255 formulation was mixed as recommended except that Epi-Cure 859 was used in the converter portion. The 632–1895 formulation is not included in the Proceedings' references above but is shown in Table 4 herein. This is a cement coating, containing white portland cement, sand and sufficient water to hydrate the cement.

3. Test Specimens

The concrete test specimens were 1- by 3-in, 8 in long, proportioned, mixed and cured in accordance with the aforementioned acceptance specifications. Each specimen was marked with an identifying number prior to application of the coating.

All formulations were proportioned by weight, hand mixed with wooden paddles and applied to the specimens with a brush. No coverage recommendation was furnished by the manufacturer, so the thickness of the coat was a function of the room temperature viscosity of the coating. The 100-percent-solids systems were applied immediately after mixing, but the solvent systems were permitted to age 1 hr in the mixing container before application. For all two-coat systems, the first coat was permitted to harden for 24 hr before applying the second coat. These procedures were recommended by the manufacturer.

After application, the coatings were allowed to cure at room temperature, each specimen resting on three nail points. After the coatings had hardened, these nail-point holes were touched up with additional coating material. All coated specimens were then cured in a 90 F oven for seven days, in accordance with the specifications.

In general, three specimens were coated with each formulation. However, as indicated in Table 3, the P2–C1 coating required an additional specimen, No. 29, because of an omission in tabulating the data. Another additional specimen, No. 25, was used for the 632–1255 coating as one of the concrete specimens was found to have cracked after the first coat of this material had been applied.

4. Test Procedure

The acceptance tests outlined in the specifications are essentially a measure of the amount of water which the coated concrete specimen actually absorbs compared to the amount that it could absorb, expressed as an efficiency percentage. The concrete specimens were weighed in their saturated condition and then oven dried to remove all moisture. The difference between these two weights was the maximum amount of moisture which the specimen could absorb. As outlined in the acceptance-test procedure, the coated specimens were subjected to an initial immersion test during which they were immersed in water at room temperature for three days. The specimens were then subjected to a freeze-thaw test which consisted of 50 cycles of freezing at 0 F for 3 hr

(Text continued on page 71)

Photograph 2—Inspection of specimens after an immersion cycle.

Photograph 3—Specimens in position for freezing cycle.

TABLE 3. STANDARD AREA ACCEPTANCE TEST FOR WATERPROOFING COATINGS

No.	Type of Coating	W_1	W_2	W_3	W_c	Initial Immersion					Final Immersion				
									E					E	
						W_4	d	D	%	Ave.	W_4	d	D	%	Ave.
1	P2	983	926	942	16	947	52	57	91	90	966	33	57	58	54 A
2	1 coat	999	945	962	17	967	49	54	91		985	31	54	57	
3		969	917	934	17	940	46	52	88		962	24	52	46	
4	P2	951	897	923	26	925	52	54	96	94	960	17	54	31	44 A
5	2 coats	994	936	962	26	965	55	58	95		998	22	58	38	
6		982	930	957	27	962	47	52	90		977	32	52	62	
7	P2-	992	939	969	30	975	47	53	89	92	989	33	53	62	64 A
8	1st coat	1011	957	990	33	992	52	54	96		1008	36	54	67	
9	C1-	997	942 B	973	31	977	51	55	93		997	31	55	56	
29	2nd coat	1055	999	1029	30	1035	50	56	89		1046	39	56	70	
10	632-1255	992	936	945 C	9	948	53	56	95	91 A	964	37	56	66	60 A
11	2 coats	1006	948	956	8	960	54	58	93		979	35	58	60	
12		1000	942	950	8	963	45	58	78		985	23	58	40	
25		965	908	918	10	920	55	57	96		933	42	57	74	
13	C1	977	922	945	23	962	38	55	69	86 A	998	2	55	4	45 A
14	2 coats	973	915	948	33	951	55	58	95		975	31	58	53	
15		980	924	959	35	962	53	56	95		972	43	56	77	
16	P1	1048	990	1010	20	1014	54	58	93	95	1020	48	58	83	86
17	(flex)	966	908	926	18	928	56	58	97		933	51	58	88	
18	2 coats	969	913	931	18	934	53	56	95		939	48	56	86	
22	632-1895	992	933	948	15	998	9	59	15	22 A	1000	7	59	12	14 A
23	1 coat	1003	943	960	17	1006	14	60	23		1011	9	60	15	
24		989	934	949	15	988	16	55	29		996	8	55	15	
26	C1	1014	956	984	28	991	51	58	88	85	1026	16	58	28	32 A
27	1 coat	977	921	957	36	965	48	56	86		1004	9	56	16	
28		995	938	955	17	966	46	57	81		983	29	57	51	
1a	P1	944	893	909	16	911	49	51	96	99	920	40	51	78	84 A
2a	1 coat	936	890	905	15	905	46	46	100		910	41	46	89	
3a		914	867	883	16	883	47	47	100		890	40	47	85	
4a	632-1555	956	906	907	1	915	42	50	84	84 A	922	35	50	70	66 A
5a	1 coat	933	887	888	1	896	38	46	83		904	30	46	65	
6a		936	892	893	1	898	39	44	89		909	28	44	64	

Weights are in grams. $W_c = W_3 - W_2$ $d = W_1 - (W_4 - W_c)$ $D = W_1 - W_2$ $E = \frac{100d}{D}$

A. Unacceptable under terms of the specification. B. Estimated Weight C. Specimen has crack.

TABLE 4. FORMULATION 632-1895 EPI-REZ 285 CEMENT COATING

Part A	Lbs.	Gals.	Material
	100.0	2.86	Rutile Titanium Dioxide, N.C.
	100.0	4.22	Magnesium Silicate (Fine Textured)
	4.0	0.28	Bentone 27* (National Lead)
	1.9	0.28	Methanol*
	227.0	26.00	Epi-Rez**285
	43.1	5.55	Ethyl Cellosolve
			Grind above in 3 RM, then add following under agitation;
	47.0	1.76	White Portland Cement
	200.0	9.05	Ultra-Fine Sand (100 mesh)
	723.0	50.00	Visc. - off scale; Wt/Gal - 14.46
Part B	50.0	2.11	Magnesium Silicate (Fine Textured)
	50.0	2.34	#1718 Mineral Filler (Whittier, Clark & Daniels)
	4.0	0.28	Bentone 27*
	1.9	0.28	Methanol*
	44.8	5.50	Epi-Cure**859
	15.5	2.00	Ethyl Cellosolve
	150.2	20.96	Xylol
			Grind above in 3 RM, then add following under agitation;
	125.0	5.68	Ultra-Fine Sand (100 mesh)
	200.0	10.85	FFFF Valencia Pumice (Whittier, Clark & Daniels)
	641.4	50.00	Visc. - off scale; Wt/Gal - 12.83
	1364.4	100.00	
Part C	12.5	1.50	Water
	33.6	5.00	Methyl Ethyl Ketone
	38.8	5.00	Ethyl Cellosolve
	89.2	13.50	Methanol
	174.1	25.00	Visc. - 9" #4 Ford Cup; Wt/Gal - 6.96

Blending Procedure - Blend Parts A & B on 1:1 basis then add Part C as reducer.

Reduction	1 quart Part C to one gallon blend of Parts A & B.
Reduction Viscosity	85 KU
Wt/Gal (Final Blend)	12.30
PVC	67.3%
Vehicle Solids	37.6%
Total Solids	77.8%
Application	Spray or Roller***

* Pre-Wet

** Reg. U.S. Pat. Off.

*** Spray with #7 Binks gun with #36 tip; or #18 Binks gun with #66 tip; or Equiv. Spray pressure - 60 psi on line, 25 psi on cup.

(Test continued from page 66)

followed by thawing in water at 130 F for 1 hr. (See Photographs 2 and 3.) This was followed by a final immersion test of three days in water at room temperature. The time schedule stipulated in the specifications was rigidly adhered to.

5. Test Results

To be acceptable under the terms of the specification, the efficiency of any coating must be 85 percent or higher as determined by the average of three test specimens. If the efficiency of any one of the specimens falls below 85 percent, it cannot vary more than 5 percent from the average. The acceptance tests further stipulate that if the coating fails to qualify after the initial immersion test, the freeze-thaw test need not be performed.

It can be seen from Table 3 that the 632–1895 coating attained an efficiency of only 22 percent after the initial immersion. Even though this coating is not acceptable under the terms of the specification, the additional test procedure was conducted anyway for general information. It can also be seen that coating 632–1555 also failed the inital immersion test, with an efficiency of 84 percent. The C1 two-coat system attained an average efficiency of 86 percent. However, one of the three specimens was only 69 percent; therefore, this coating was not acceptable under the initial immersion test. The 632–1255 two-coat coating also failed the initial immersion test.

As indicated in Table 3, only one coating attained an efficiency greater than 85 percent and was acceptable under the terms of this test. This coating consisted of two coats of formulation P1 (flexibilized).

In the inspection of all the specimens after the initial immersion, no coating failures were apparent. There were small pin holes in the surfaces of many of the coatings, and this may have contributed to the low efficiency of some. The cement coating, 632–1895, seemed to absorb water, which may have accounted for its low efficiency. The other coatings repelled water.

After the final immersion and the conclusion of the test, the specimens were carefully inspected and the following observations made:

Specimens 1, 2 and 3—no visible evidence of coating failure.
Specimens 4, 5 and 6—numerous long cracks in coatings of all specimens.
Specimens 7, 8, 9 and 29—one or more small cracks on each specimen.
Specimen 10—no evidence of coating failure.
Specimens 11, 12 and 25—small chips out of corner and edges.
Specimens 13 and 14—long cracks in coating.
Specimens 15, 16, 17, 18, 22 and 23—no evidence of coating failure.
Specimen 24—small chip out of edge.
Specimen 26—small crack on one side.
Specimen 27—large cracks on both sides, coating broken away from concrete.
Specimen 28—no evidence of coating failure.
Specimens 1a, 2a, 3a, 4a, 5a and 6a—no evidence of coating failure.

The most apparent evidence of coating failure was the development of cracks in the coating during the freeze-thaw cycles. This cracking seemed to be a function of the coating thickness. Considering only the 100-percent-solids systems, the following conditions were noted:

1 coat	*2 coats (flex)*	*2 coats*
Spec. 1 —no cracks	Spec. 16—no cracks	Spec. 4—cracks
2 —no cracks	17—no cracks	5—cracks
3 —no cracks	18—no cracks	6—cracks
1a—no cracks		7—cracks
2a—no cracks		8—cracks
3a—no cracks		9—cracks
		29—cracks
		13—cracks
		14—cracks
		15—no cracks
		26—cracks
		27—cracks
		28—no cracks

The above indicates that a two-coat 100-percent-solids system is subject to cracks, probably because the greater thickness of the coating makes it unable to adjust to the temperature differential. The single coatings were, of course, thinner and no such cracking was observed. The flexibilized coating was also a two-coat system, but the increased amount of converter made this a less viscous liquid and resulted in a thinner coating. Its flexibility may also be a desirable property for resistance to freezing and thawing.

No cracks in any of the solvent-system coatings were evident. These were relatively thin coatings and apparently were able to adjust to the large changes in temperature.

6. Acknowledgments

The concrete blocks were furnished by the Portland Cement Association. The coating materials were furnished by The Clinton Company, Federated Paint Manufacturing Company, and the Jones–Dabney Company.

Advance Report of Committee 15—Iron and Steel Structures

Report on Assignment 3

Corrosion of Deck Plates

J. E. South (chairman, subcommittee), E. T. Franzen, R. S. Bennett, E. T. Bond, E. F. Garland, G. W. Haffey, W. C. Howe, E. A. Johnson, M. L. McCauley, D. L. Nord, J. Payne, A. L. Piepmeier, C. A. Roberts, W. E. Robey, R. D. Spellman.

Corrosion of Deck Plates After Five Years of Exposure

A. DIGEST

The metal plates that form the trough on ballasted-deck bridges are subjected to a severely corrosive environment created by brine falling from refrigerator cars. A variety of metals is available for this use, but no comparative data are available on their resistance to corrosion in such an environment. To obtain such data the AAR research staff began an investigation in 1958 in which metal test plates were placed in a briny environment both in the field and in the laboratory. This paper presents the data obtained after 5 years of exposure. Future reports will present the data obtained after exposures of 10 years and 15 years, respectively.

The field test plates, 7 by 10 in. in size, were installed on the Huey Long Bridge, New Orleans, La. The laboratory test plates, 12 by 12 in, were placed in ballast-filled boxes at the AAR Research Center, Chicago. At both locations, after 5 years of exposure, only plates of stainless steel and 6061–T6 aluminum indicated any significant resistance to corrosion. Alclad 2014 aluminum plates were unaffected by exposure to brine in the ballast-filled boxes, but plates of identical metal on the bridge were seriously laminated after five years because of the more severe conditions there.

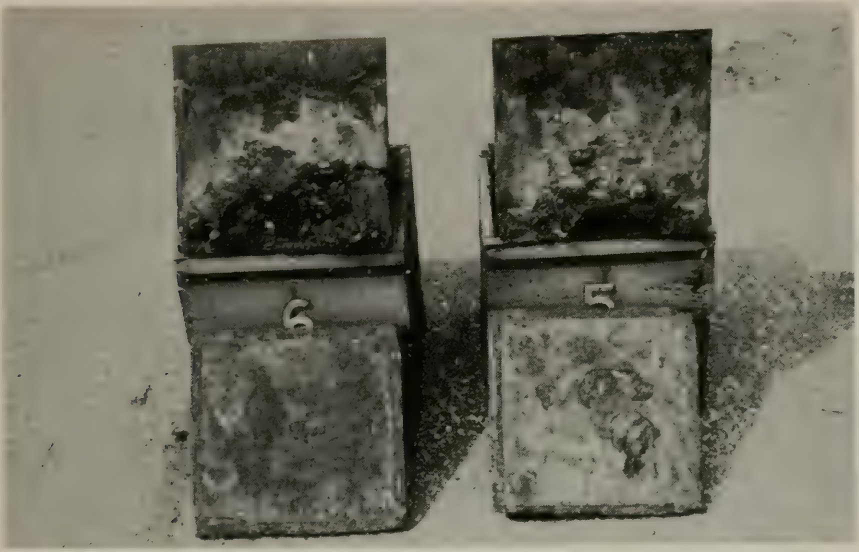
The average weight losses of the plates in the ballast boxes (except the stainless steel and aluminum plates) ranged from 12.3 to 17.6 percent. The weight losses of the same plates on the bridge ranged from 28.8 percent to 36.5 percent. The small spread between the extremes at both locations indicates that all these metals suffered about the same amount of corrosion after 5 years of exposure. The depth of pitting was severe at both locations, ranging from 0.11 to 0.29 in for the plates in the ballast boxes and from 0.25 to 0.35 in for the plates on the bridge.

B. FOREWORD

Committee 15—Iron and Steel Structures, under its Assignment 3—Corrosion of Deck Plates, sponsors this investigation and has requested funds each year for its support. The AAR provides the laboratory facilities and personnel as part of the research activity of the AAR Research Department, of which W. M. Keller is vice president and G. M. Magee is director of engineering research. The conduct of the investigation, analysis of the data and the preparation of this report were under the general direction of E. J. Ruble, executive research engineer, assisted by F. P. Drew, research engineer structures. I. A. Eaton, laboratory engineer, and R. Trubic, laboratory assistant, maintained the specimens at the Research Center. E. F. Garland, bridge supervisor, New Orleans Public Belt Railroad, maintained the specimens on the Huey Long Bridge. This report was written by Mr. Drew.

Photograph 1—Inspection party at test plot, AAR Research Center.

Photograph 2—Closeup view of ballast boxes at Research Center, showing vertical test plates.



Photograph 3—Vertical and bottom test plates after removal from boxes.

C. TEST LOCATIONS

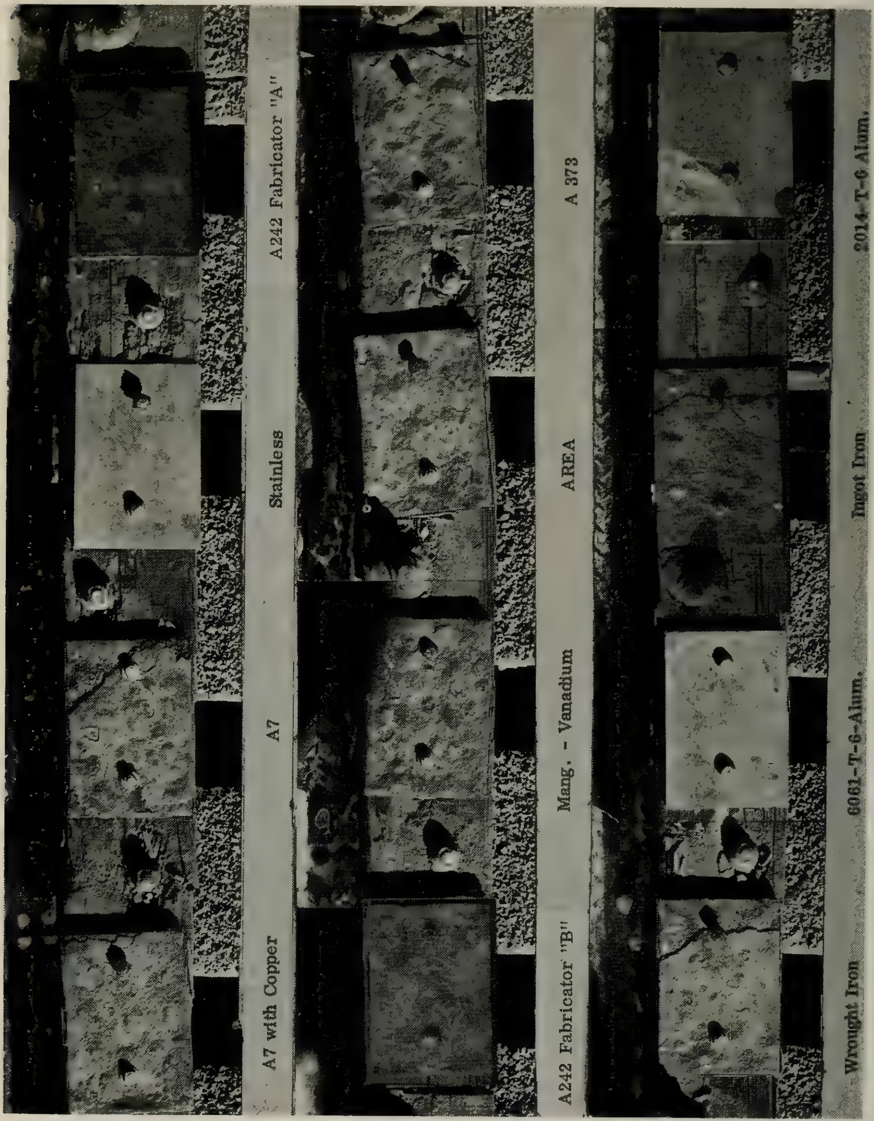
AAR Research Center

An overall view of the test plot at the AAR Research Center is shown in Photograph 1. Boxes were made to receive two 12-in-square plates each, one plate forming the bottom of a box and the other positioned vertically. These two plates so positioned thus simulated the bottom and sides of a ballast trough. The boxes were filled with ballast removed from an adjacent track, leaving the vertical plates projecting about 2 in above the ballast, as shown on Photograph 2. Each work day a cupful of a 5-percent solution of sodium chloride (salt) was sprinkled uniformly over the top of each box. Since the test plot was outdoors, the plates were exposed to atmospheric corrosion and natural weather elements in addition to the manually administered salt solution.

Huey Long Bridge

Considerable corrosion has been encountered on the Huey Long Bridge, particularly under the eastbound track on the west approach, where a 4-deg curve and 1.11-percent grade combine to increase the amount of brine dropped from refrigerator cars. Other contributing factors are the temperate climate and high humidity of the region.

Arrangements were made with the New Orleans Public Belt to install 6 sets of 7- by 10-in plates, 12 different metals in each set, on the inside spacer timber of the open timber floor. The plates are held in place with lag screws, as shown in Photograph 4. Fig. 1 shows the location of the plates. Set 1 was installed on tangent, sets 2, 3, 4, 5 and 6 were placed on the curve. Photograph 4 shows the general arrangement. The plates evaluated for this report were those in sets 3 and 5. All the plates at this location were installed on July 27, 1958.



Photograph 4—Test plates on Huey Long Bridge.

D. TEST SPECIMENS

The 12 different metals evaluated at both test locations were as follows:

A 7 steel (with copper)
A 7 steel (plain)
A 242 steel (from fabricator "A")
A 242 steel (from fabricator "B")
A 373 steel
AREA steel
Manganese—vanadium steel
Wrought iron
Ingot iron
Stainless steel—No. 316
6061–T6 aluminum
2014–T6 Alclad aluminum

The 12- by 12-in plates for the test plot at the AAR Research Center and the 7- by 10-in plates for the Huey Long Bridge were obtained in the thicknesses available at the time the program was set up.

A chemical analysis was made of samples of the plates from which the 12-in by 12-in specimens were cut. Table 1 shows the percentages of the various elements present.

Plates for this investigation were furnished by the following companies:

Aluminum Company of America
Armco Steel Corporation
Bethlehem Steel Company
A. M. Byers Company
United States Steel Corporation

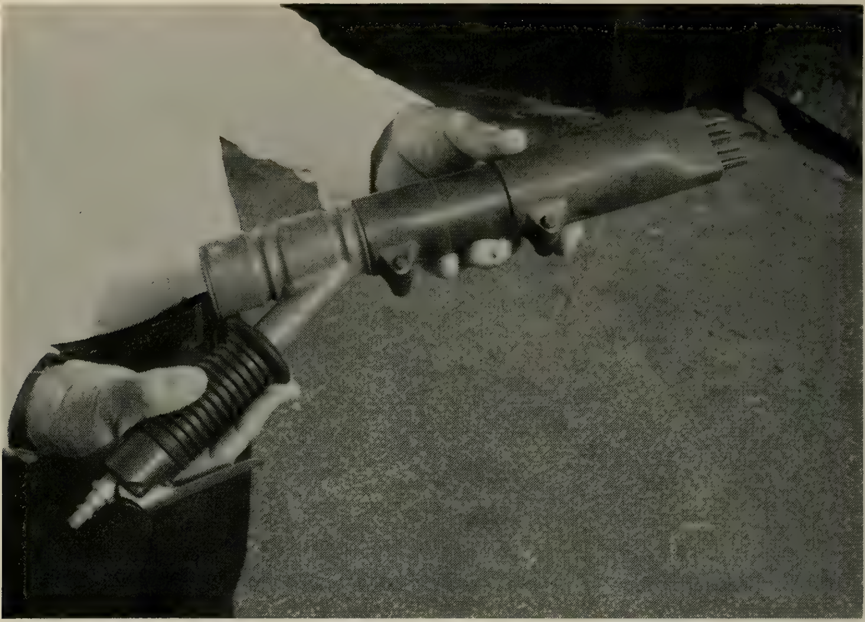
E. CLEANING AND WEIGHING

On April 29, 1959, after 9 months of exposure at the Research Center, the 12- by 12-in plates were removed from their boxes for a preliminary inspection and weighing. Dirt, loose rust and loose scale were removed with a bristle brush, but no effort was made to remove rust blisters or tight scale. Since it was evident that considerable rust and scale were still intact when the plates were weighed, the weight changes have little meaning and are not reported herein.

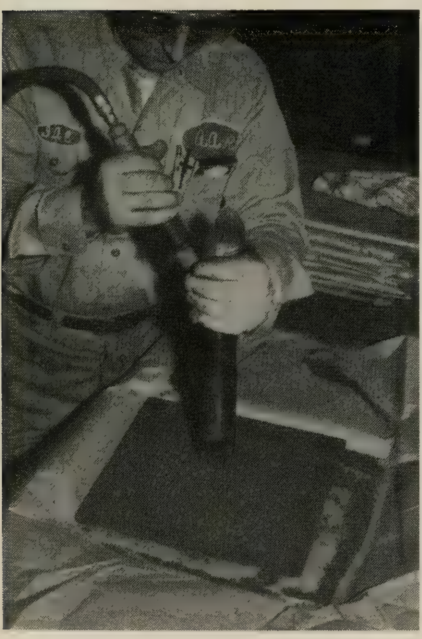
On February 5, 1960, after 19 months of exposure on the Huey Long Bridge, some of the 7- by 10-in plates were removed for a preliminary inspection and weighing. Here, also, special care was taken not to remove rust blisters or tight scale. The plates were weighed, and most were found to be heavier than when originally installed, indicating that considerable rust, scale and moisture were present. These weight changes are also not reported herein.

After these preliminary inspections the plates were left undisturbed in the boxes at the Research Center and on the Huey Long Bridge until removed at the end of the five-year exposure period.

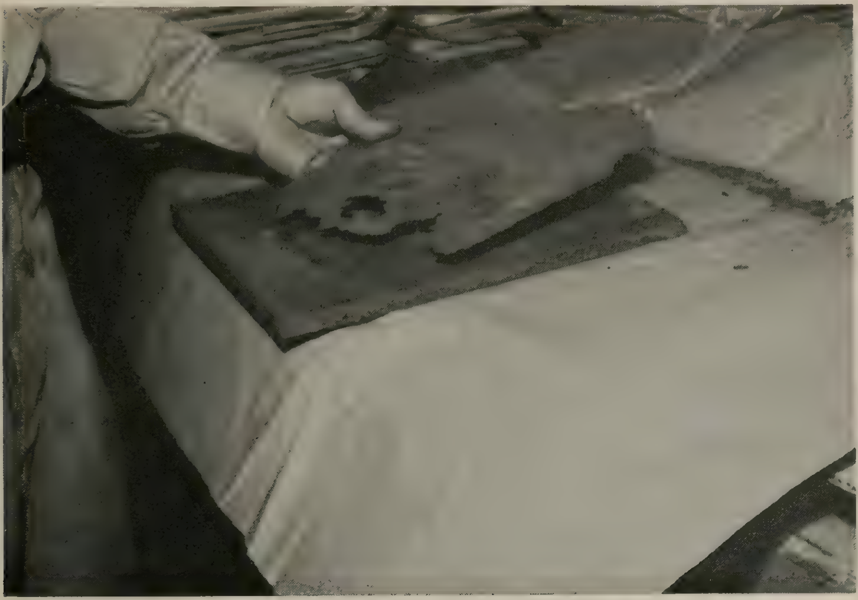
All the plates (except those of stainless steel and aluminum) at both exposure locations showed extensive corrosion (see Photographs 3 and 4) and appeared to be corroded to about the same degree. Thus, their identity was no longer apparent from the original identifying punch marks, as these were no longer visible. However, throughout



Photograph 5—Needle gun used for cleaning plates.



Photograph 6—Needle gun in operation.



Photograph 7—Some scale could be lifted off in sheets.

the exposure period, Mr. Garland maintained a careful record of plate location, and identity was readily established by position on the bridge. At the Research Center identity of the different metals in the ballast boxes was tied to a numbering system. Extreme care was taken to individually wrap each plate as it was removed from its position on the bridge and from each ballast box. The outside of each wrapper was marked to show position on the bridge or ballast-box number, and kind of metal. During cleaning, only one plate was unwrapped at a time. The plates were kept wrapped until after weighing, at which time an identification mark was put on each plate with white paint.

All plates, except those of stainless steel and aluminum, were cleaned first by wire brushing to remove loose material and then by use of a pneumatic needle gun to remove all scale down to solid metal. All the plates had heavy, loose scale, some of which could be lifted off in sheets, as shown in photograph 7. The needle gun in use is shown in photograph 6; a closeup view is shown in photograph 5. The devise consists essentially of a reciprocating piston which strikes a group of 28 tempered steel needles. These needles are about ⅛ in. in diameter and have chisel points. Each impinges against a surface independently of the others, hence ridges and valleys are given equal treatment. No attempt was made to remove rust stain or to obtain a "white metal" appearance. Cleaning was stopped when all scale had been removed and it was apparent that only discoloration remained. This method of cleaning was adopted in preference to sandblasting or chemical cleaning to avoid the possibility of removing base metal. The needle gun was loaned to the AAR through the courtesy of the Bridge Department of the Illinois Central Railroad. The stainless steel plates (which had only a dark film on their surfaces) and the aluminum plates (which had a white film) were cleaned with a power wire brush to bright metal.

Immediately following the cleaning operation, the plates were weighed, using the same scales that had been used for the original weighing in 1958. To verify accuracy of the scale readings, a 12- by 12-in steel plate that had been weighed with the original test plates and kept wrapped in dry storage during the test period was again weighed. Since the scale readings were the same in both weighings of the check plate, scale accuracy was verified.

F. TEST RESULTS

The actual original weights, the final weights and the weight losses for the plates removed from the AAR ballast boxes are shown in Table 2. The same data for the plates from the Huey Long bridge are shown in Table 3. Col. 3 of each table indicates that the majority of the plates was $\frac{9}{16}$ in thick, and that some were $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{5}{8}$ in thick. To compare the percentage weight losses of the various plates it was necessary to convert their thicknesses to a common figure, taken as $\frac{9}{16}$ in. Cols. 7 and 8, therefore, show adjusted original plate weights and weight losses. Such adjustment was made only to those plates which had a nominal original thickness other than $\frac{9}{16}$ in. No adjustment was made to the weights of the stainless steel or aluminum plates. The original plate weight was adjusted by multiplying the actual original weight by the following factor:

$$\frac{\frac{9}{16}\text{ in}}{\text{nom. orig. thickness (inches)}}$$

The weight loss was adjusted by multiplying the actual loss by the factor:

$$\frac{\text{surface area of a }\frac{9}{16}\text{-in plate}}{\text{surface area of a plate other than }\frac{9}{16}\text{ in}}$$

The percentage weight losses shown in Col. 9 were computed using the actual weights from Cols. 4 and 6, except where adjusted weights are shown. The average of the values in Col. 9 are shown in Col. 10 for each type of metal.

The plates from each exposure location were observed to be deeply pitted. The thickness of the metal remaining at the base of the pits was measured with a caliper graduated to read to 0.01 in. The 12- by 12-in plates were marked off into 36 equal squares and the 7- by 10-in plates into 15 equal squares. Using the caliper, the least thickness of metal remaining was determined for each square. Table 4 shows the six lowest values for the ballast-box plates and Table 5 shows the three lowest values for the smaller, Huey Long Bridge plates. The difference between the lowest of these values and the nominal original thickness is a measure of the total depth of pitting on both sides of the plate.

AAR Ballast-Box Plates

From the figures shown in Col. 10 of Table 2, it is readily apparent that only stainless steel and aluminum offered significant resistance to corrosion in the briny environment. Of the other metals, the manganese–vanadium plates had the least corrosion and ingot iron the most. However, the spread between the two extremes was only 5.3 percent, indicating that all the plates had corroded to nearly the same degree.

Plain A 7 steel showed slightly less corrosion than copper-bearing A 7 steel and only slightly more than A 242, A 373, AREA and manganese–vanadium steel and wrought iron. It was noted also that the $\frac{1}{4}$-in-thick plain A 7 plate and the $\frac{1}{4}$-in-thick wrought-iron plate had nearly equal amounts of corrosion.

As noted in Col. 2 of Table 2, the plates were marked with a letter "V" and "H". This indicates the position of the plate in the box as vertical or horizontal. Since the range of the weight loss percentages was small, it is difficult to establish the effect of plate position on corrosion. For the nine types of metal that had suffered significant amounts of corrosion, three had more in the horizontal position and six had more in the vertical position.

The depth-of-pitting figures in Col. 6 of Table 4 reveal that nearly all the vertical plates were pitted deeper than the horizontal plates. (A wrought-iron plate was the only exception). The reason probably was that pits were present on both sides of a plate at the point of measurement, and the instrument measured the total depth of both pits. It was also noted that the lower portion of the vertical plates was corroded and pitted more than the top portion (which projected above the ballast). The two ¼-in thick plates which were mounted vertically (A 7 plain and wrought iron) each developed a ragged, feathered lower edge, which did not occur in any of the thicker plates. In most cases the horizontal bottom plate was corroded and pitted more on the surface next to the ballast. The depth of pitting was least for the wrought iron, 0.11 in, and greatest for the A 7 steel with copper, 0.29 in.

Huey Long Bridge Plates

The figures shown in Col. 10 of Table 3 indicate that on the bridge only stainless steel and the 6016–T6 aluminum offered any significant resistance to corrosion. Of the other metals, wrought iron showed the least corrosion and the AREA steel the most, but the spread between the two extremes was only 7.7 percent, indicating that all had nearly the same amount of corrosion.

The Alclad 2014–T6 aluminum plates at this location exhibited a distinct lamination and separation. It was first observed in November 1960, that cracks were forming along the edges. These developed into splits, and large pieces of the top layers had broken off by the time the plates were taken up at the end of the 5-year exposure period. No such cracking or splitting was observed in identical plates at the Research Center; however, the exposure at the Huey Long Bridge was much more severe.

The depth of pitting is indicated in Col. 6 of Table 5. The least depth is shown to be on the A 242 plate of fabricator "B", 0.25 in, and the greatest depth on the plate of AREA steel, 0.35 in.

TABLE 1 - CHEMICAL COMPOSITION OF PLATES

	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	V	Ti	Mg	Fe	Zn	Others
A7 steel (with copper)	0.22	0.50	0.012	0.021	0.06	<0.05	<0.05	<0.03	0.25						
A7 steel (plain)	0.25	0.55	0.012	0.020	0.06	<0.05	<0.05	<0.03	<0.05						
Stainless steel No. 316	0.04	1.79	0.010	0.018	0.30	13.56	17.25	2.31	<0.05						
A242 steel (Fabricator "A")	0.11	0.27	0.012	0.023	0.30	0.28	0.80	<0.03	0.34						
A242 steel (Fabricator "B")	0.11	0.68	0.011	0.024	0.29	0.75	0.56	<0.03	0.27						
Manganese - Vanadium steel	0.14	1.02	0.011	0.020	0.22	<0.05	<0.05	0.03	0.32	0.07					
AREA steel	0.24	1.55	0.013	0.024	0.22	<0.05	<0.05	0.03	0.27						
A373 steel	0.19	0.92	0.011	0.021	0.05	<0.05	<0.05	<0.03	<0.05						
Wrought iron (Note 1)	<0.02	0.02	0.019	0.020	0.13	<0.05	<0.05	<0.03	0.29						
Ingot iron	0.03	<0.03	0.011	0.021	<0.02	<0.02	<0.02	<0.02	0.07						
Aluminum 6061 T6		0.09			0.59		0.20		0.36		0.08	0.94	0.35	<0.10	<0.05 ea. <0.15 tot.
Aluminum Alclad 2014 T6 (Note 2)		<0.05			0.71		0.23		0.05		<0.05	1.05	0.29	<0.10	<0.05 ea. <0.15 tot.

Note 1. Metallographic examination showed high-silicon stringers uniformly distributed throughout the microstructure.
Note 2. Sample showed visible areas of marked segregation which were also observed during spectrographic excitation.

TABLE 2 - WEIGHT LOSS - AAR BALLAST BOX PLATES

Description of Metal	Mark	Nominal original thickness	Actual original weight lbs	Final weight lbs	Weight loss lbs	Adjusted original weight lbs	Adjusted weight loss lbs	Weight loss %	Weight loss average %
1	2	3	4	5	6	7	8	9	10
A7 (with copper)	1V	9/16"	25.00	20.50	4.50			18.0	16.7
"	1H	"	24.50	20.72	3.78			15.4	
A7 (plain)	2V1	"	24.55	20.79	3.76			15.3	15.6
"	2H1	"	24.33	20.93	3.40			14.0	
"	2V2	1/4"	10.94	6.85	4.09	24.62	4.30	17.5	
A242 (Fabricator "A")	5V	9/16"	23.65	20.29	3.36			14.2	14.7
" "	5H	"	23.69	20.10	3.59			15.2	
A242 (Fabricator "B")	6V	"	24.45	21.58	2.87			11.7	12.5
" "	6H	"	24.14	20.96	3.18			13.2	
A373	9V	"	24.36	20.98	3.38			13.9	14.0
"	9H	"	24.81	21.32	3.49			14.1	
AREA	8V	"	23.23	20.11	3.12			13.4	12.5
"	8H	"	23.01	20.35	2.66			11.6	
Manganese-Vanadium	7V	"	25.55	22.36	3.19			12.5	12.3
"	7H	"	24.72	21.75	2.97			12.0	
Wrought Iron	10V1	1/2"	20.29	16.62	3.67	22.83	3.70	16.2	13.6
"	10H1	"	20.66	18.42	2.24	23.24	2.26	9.7	
"	10V2	1/4"	10.27	6.38	3.89	23.11	4.09	17.7	
"	11V	5/8"	26.08	23.52	2.56	23.47	2.54	10.8	
"	11H	"	26.02	22.80	3.22	23.42	3.19	13.6	
Ingot Iron	13V	3/8"	15.51	11.16	4.35	23.27	4.47	19.2	17.6
"	13H	"	15.64	12.00	3.64	23.46	3.75	16.0	
Stainless	3V	1/2"	21.17	21.16	0.01			0.1	0.2
"	3H	"	21.39	21.32	0.07			0.3	
Aluminum 6061 T6	12V	"	7.00	6.99	0.01			0.1	0.3
" "	12H	"	7.00	6.97	0.03			0.4	
Aluminum Alclad 2014 T 6	14V	"	7.79	7.79	0.00			0.0	0.1
" "	14H	"	7.77	7.76	0.01			0.1	

TABLE 3 - WEIGHT LOSS - HUEY LONG BRIDGE PLATES

Description of Metal	Mark	Nominal original thickness	Actual original weight lbs	Final weight lbs	Weight loss lbs	Adjusted original weight lbs	Adjusted weight loss lbs	Weight loss %	Weight loss average %
1	2	3	4	5	6	7	8	9	10
A7 (with copper)	1-3	9/16"	10.88	6.98	3.90			35.9	33.3
"	1-5	"	11.01	7.64	3.37			30.6	
A7 (plain)	2-3	"	11.21	7.21	4.00			35.7	34.7
"	2-5	"	11.19	7.43	3.76			33.6	
A242 (Fabricator "A")	5-3	1/2"	10.01	6.43	3.58	11.26	3.61	32.1	30.3
" "	5-5	"	9.87	6.75	3.12	11.10	3.15	28.4	
A242 (Fabricator "B")	6-3	9/16"	10.90	7.38	3.52			32.3	31.7
" "	6-5	"	10.93	7.53	3.40			31.1	
A373	9-3	"	10.74	7.17	3.57			33.2	35.2
"	9-5	"	10.80	6.79	4.01			37.1	
AREA	8-3	"	10.86	6.78	4.08			37.6	36.5
"	8-5	"	10.93	7.06	3.87			35.4	
Manganese-Vanadium	7-3	"	11.01	7.81	3.20			29.1	29.5
"	7-5	"	11.04	7.74	3.30			29.9	
Wrought Iron	10-3	1/2"	9.81	6.97	2.84	11.04	2.87	26.0	28.8
"	10-5	"	9.86	6.39	3.47	11.09	3.50	31.6	
Ingot Iron	13-3	3/8"	7.44	4.09	3.35	11.16	3.45	30.9	31.8
"	13-5	"	7.73	4.05	3.68	11.60	3.79	32.7	
Stainless	3-3	1/2"	10.31	10.31	0.00			0.0	0.1
"	3-5	"	10.36	10.35	0.01			0.1	
Aluminum 6061 T6	12-3	"	3.35	3.38	--			--	--
" "	12-5	"	3.37	3.38	--			--	--
Aluminum Alclad 2014 T6	14-3	"	3.80	3.97A	--			--	--A
" "	14-5	"	3.81	3.69B	--			--	--B

Note A. Plate shows lamination with foreign matter between plies.

Note B. Same as A, also has piece broken off.

TABLE 4 - DEPTH OF PITTING - AAR BALLAST BOX PLATES

Description of Metal	Mark	Thickness of Metal Remaining at Base of Pits Six lowest values - inch						Minimum Value Inch	Nom. Orig. Thickness Inch	Depth of Pits Inch
1	2	3						4	5	6
A7 (with copper)	1V	.27	.33	.35	.35	.36	.36	.27	.56	.29
"	1H	.39	.39	.40	.40	.41	.41	.39	"	.17
A7 (plain)	2V1	.34	.37	.38	.36	.37	.40	.34	"	.22
"	2H1	.43	.41	.43	.43	.44	.40	.40	"	.16
"	2V2	.05	.04	.03	.05	.05	.03	.03	.25	.22
A242 (Fabricator "A")	5V	.38	.41	.41	.40	.42	.40	.38	.56	.18
" "	5H	.40	.41	.40	.42	.41	.42	.40	"	.16
A242 (Fabricator "B")	6V	.40	.42	.39	.41	.40	.36	.36	"	.20
" "	6H	.42	.42	.42	.42	.42	.41	.41	"	.15
A373	9V	.36	.35	.40	.40	.39	.38	.35	"	.21
"	9H	.41	.41	.38	.42	.37	.40	.37	"	.19
AREA	8V	.36	.32	.39	.36	.38	.37	.32	"	.24
"	8H	.43	.42	.43	.41	.43	.43	.41	"	.15
Manganese-Vanadium	7V	.42	.40	.35	.38	.43	.42	.35	"	.21
"	7H	.42	.44	.44	.42	.43	.43	.42	"	.14
Wrought Iron	10V1	.35	.35	.35	.35	.35	.36	.35	.50	.15
"	10H1	.42	.40	.41	.39	.41	.42	.39	"	.11
"	10V2	.10	.10	.10	.10	.09	.10	.09	.25	.16
"	11V	.52	.53	.52	.52	.53	.53	.52	.63	.11
"	11H	.50	.50	.48	.47	.50	.49	.47	"	.16
Ingot Iron	13V	.20	.19	.20	.15	.21	.21	.15	.38	.23
"	13H	.22	.18	.21	.20	.20	.22	.18	"	.20

TABLE 5 - DEPTH OF PITTING - HUEY LONG BRIDGE PLATES

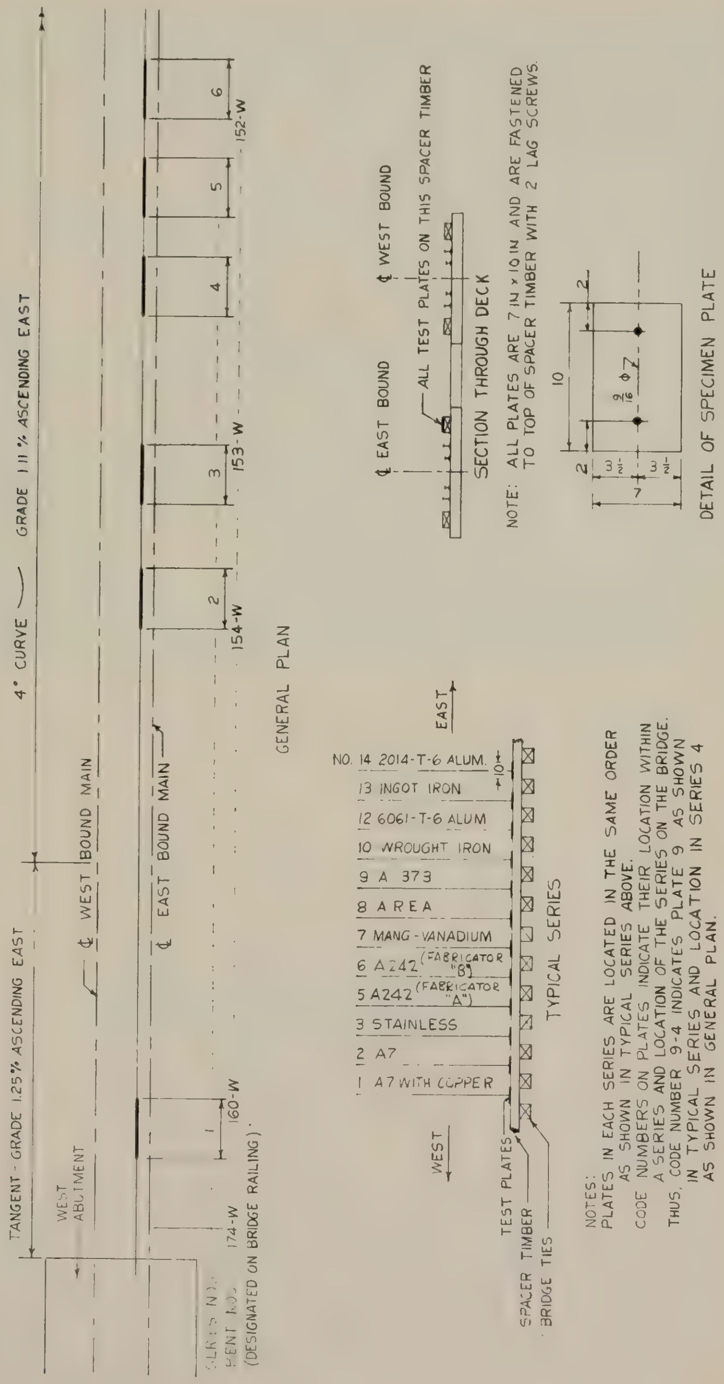
Description of Metal	Mark	Thickness of Metal Remaining at Base of Pits Three lowest values - inch			Minimum Value Inch	Nom. Orig. Thickness Inch	Depth of Pits Inch
1	2	3			4	5	6
A7 (with copper)	1-3	.27	.31	.27	.27	.56	.29
"	1-5	.25	.23	.24	.23	"	.33
A7 (plain)	2-3	.27	.24	.26	.24	"	.32
"	2-5	.23	.26	.31	.23	"	.33
A242 (Fabricator "A")	5-3	.22	.25	.26	.22	.50	.28
" "	5-5	.20	.21	.23	.20	"	.30
A242 (Fabricator "B")	6-3	.31	.31	.32	.31	.56	.25
" "	6-5	.28	.28	.25	.25	"	.31
A373	9-3	.24	.27	.27	.24	"	.32
"	9-5	.24	.24	.26	.24	"	.32
AREA	8-3	.21	.27	.25	.21	"	.35
"	8-5	.24	.25	.25	.24	"	.32
Manganese-Vanadium	7-3	.23	.29	.30	.23	"	.33
"	7-5	.22	.26	.28	.22	"	.34
Wrought Iron	10-3	.21	.25	.27	.21	.50	.29
"	10-5	.23	.26	.28	.23	"	.27
Ingot Iron	13-3	.07	.08	.09	.07	.38	.31
"	13-5	.08	.11	.12	.08	.38	.30

FIG. 1

NEW ORLEANS PUBLIC BELT RAILROAD

LOCATION OF CORROSION TEST PLATES

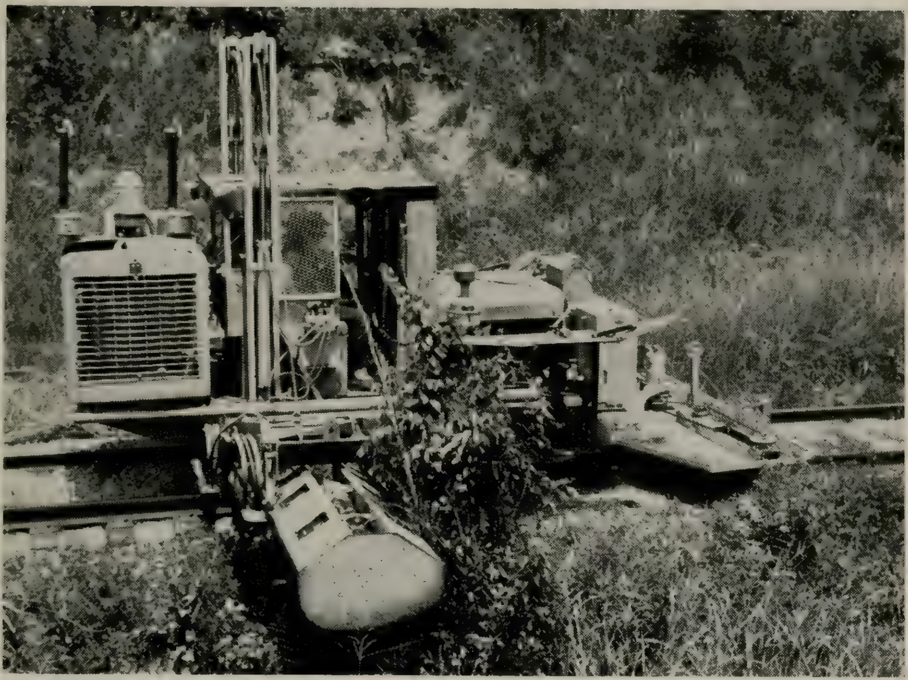
HUEY P. LONG BRIDGE - NEW ORLEANS, LA.



NOTE: ALL PLATES ARE 7 IN × 10 IN AND ARE FASTENED TO TOP OF SPACER TIMBER WITH 2 LAG SCREWS.

NOTES:
PLATES IN EACH SERIES ARE LOCATED IN THE SAME ORDER AS SHOWN IN TYPICAL SERIES ABOVE.
CODE NUMBERS ON PLATES INDICATE THEIR LOCATION WITHIN A SERIES AND LOCATION OF THE SERIES ON THE BRIDGE.
THUS, CODE NUMBER 9-4 INDICATES PLATE 9 AS SHOWN IN TYPICAL SERIES AND LOCATION IN SERIES 4 AS SHOWN IN GENERAL PLAN.

KERSHAW Trackwork Machines

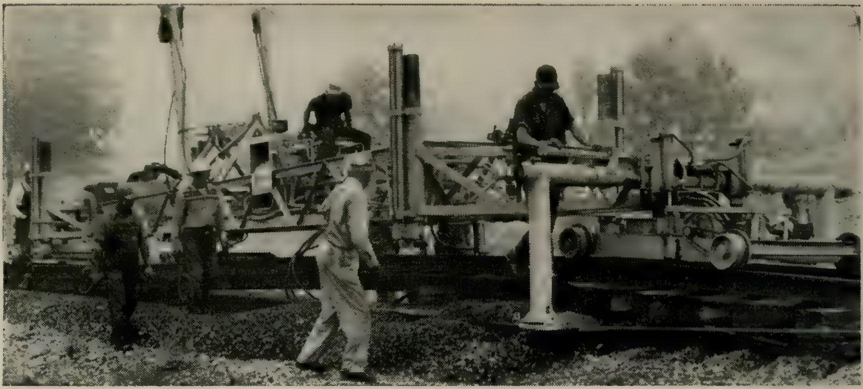


Weed And Brush Cutter (Track Patrol)
Designed, Tested, and Proven
on America's Railroads

KERSHAW
MANUFACTURING CO. INC
MONTGOMERY K ALABAMA

Trackwork Equipment Developed and Proven On the Job

Heavy Duty Ballast Regulator, Scarifier and Plow, Standard Ballast Regulator, Sacrifier and Plow, Track Broom, Super Jack-All, Standard Jack-All Kershaw Kribber, Two-Wheel Kribber, Tie Bed Sacrifier Tie Inseter, Track Undercutter-Skeletonizer, Ballast Cleaner, Crib-Adze, Mocar Crane, Track Crane and Tie Inserter, Utility Derrick, Two-Ton Rail Derrick, Tie Replacer, Dual Tie Saw, Track Liner, Snow Switch Cleaner, Weed and Brush Cutter (Track Patrol).

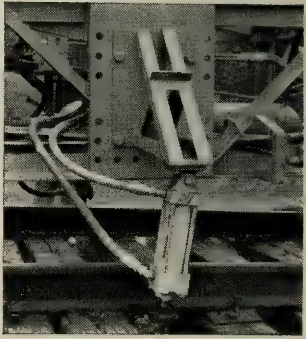


Machine knocks off, ejects ties, lines track behind plow while above subgrade.

Mannix AUTO-TRACK Eliminates 15 to 20 Men

PLOWING, TIE REPLACEMENT, TRACK ALINEMENT are accomplished faster and with fewer men using the new Mannix AUTO-TRACK unit.

Hydraulic hammer on each side knocks tie down. Conveyor belt ejects tie to either side.

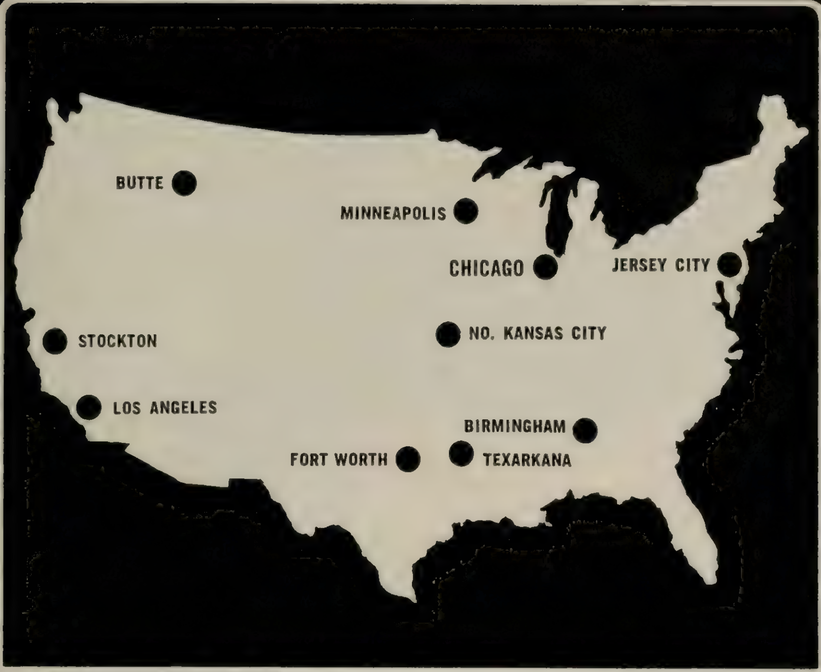


Lining head controlled by levers near rear end where operator observes alinement. One man replaces lining crew.

NOW, lease or purchase MANNIX Auto-Track Equipment to operate with railroad crew for greatest convenience and maximum savings. Write for details. Arrange showing of operating films with no obligation.

MANNIX
INTERNATIONAL
INC.

Phone: Liberty 5–0411
Box 7485
MINNEAPOLIS 22, MINNESOTA



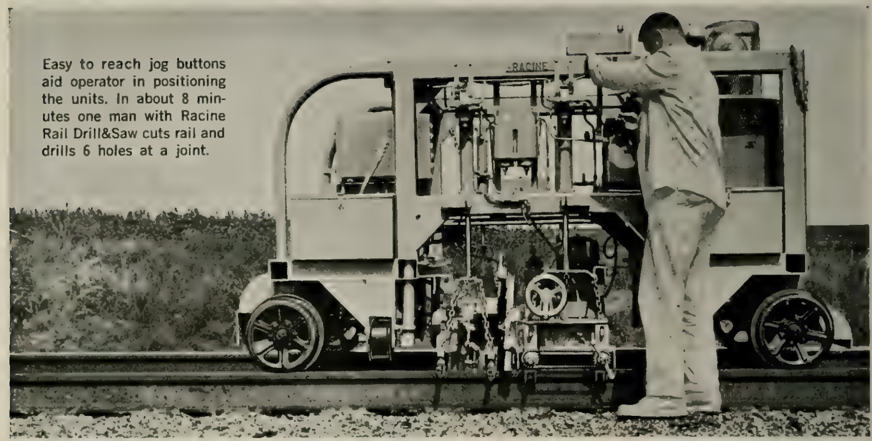
U.S. BORAX OFFERS COMPLETE VEGETATION CONTROL SERVICE AND PRODUCTS THROUGHOUT THE COUNTRY

Our railroad herbicide specialists know your regional weed, soil, and weather conditions. They have an extremely wide selection of weed and brush killing chemicals. Now, with strategically located production facilities and the most efficient spray cars in railroading today, U.S. Borax is fully equipped to contract for any vegetation control program—and carry it out promptly, effectively and economically.

We would like an opportunity to prove it to you. Write today.

3456 Peterson Avenue, Chicago 45 • INdependence 3-6262

U.S. BORAX



Easy to reach jog buttons aid operator in positioning the units. In about 8 minutes one man with Racine Rail Drill&Saw cuts rail and drills 6 holes at a joint.

UP TO 21 INSULATED JOINTS PER DAY

The Racine Rail Drill&Saw, equipped with a multiple 3 spindle drill and hydraulic feed reciprocating saw, is a dual-purpose, single operator machine for cutting-in insulated joints or cropping rail in track.

Up to 21 insulated joints per day in ribbon rail have been completed by a single machine, using the following sequence of operations:

(1) Saw rail and drill 6 holes.
(2) Expand joint with Templeton-Kenley Hydraulic Expander.
(3) Insert end post.
(4) Assemble angle bars (using electric impact wrench).

The 3 spindle drill unit may be pre-set to bore two or three holes on 5½″ to 7″ centers. Hole center adjustment is made by inserting solid spacer blocks, forming a "fixed" center drill head.

The saw unit is a new concept for reciprocating rail saws. Accurately controlled hydraulic feed pressure is used to cut rail consistently fast and straight. Blade cost is only a few cents per cut.

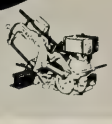
The machine is basically a self-propelled carriage and power plant for mounted saw and drill units. It is also available in various combinations of saw and drill units to suit your needs for in-track rail cropping operations. Electrical outlets on the machine give you plug-in power for impact wrench, drill bit grinder, work lights or other portable tools.

Write for more information today: Racine Hydraulics & Machinery, Inc., Dept. K94, Racine, Wisconsin. RR-150

RACINE

Unit Tamper

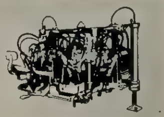
Portable Rail Drill



Portable Rail Saw

Anchor Applicator

Rail Drill&Saw



Production and Spot Tampers

ROOTS AND LOADS TIES

SPEED SWING

MODEL 441

Developed and Built
for Railroad Maintenance

180° BOOM SWING

DOES ALL JOBS!

LAYING WELDED RAIL

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
- Back Filler Blade
- Pull Drag Bucket
- 4 Cu. Yd. Snow Bucket
- Pile Hammer

Optional Attachment
Flanged Wheels, Hydraulically Controlled

9' WIDE TRACK CLEANING BUCKET

PETTIBONE MULLIKEN CORPORATION

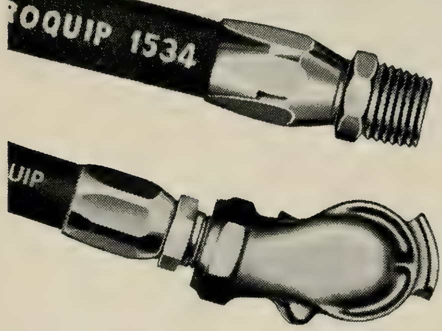
RAILROAD DIVISION
PMCO
141 W. JACKSON CHICAGO 4, ILL.

*80 Years of Service
to the Railroad Industry*

Cut Maintenance Costs With Dependable Aeroquip Hose Lines

Aeroquip Flexible Hose and Reusable Fittings are designed to cut costs two ways: Dependable replacement lines can be assembled quickly, easily in your shop as they are needed. There's no costly inventory of factory-made lines; a few coils of bulk hose and some reusable fittings meet every requirement. Second, you save on future replacements because every Aeroquip Fitting is detachable and completely reusable. Call your Aeroquip Distributor today!

AEROQUIP HOSE LINES FOR RAILROADS



For Hot Water, Fuel and Lube Oils, use Aeroquip 1534 Hose and Fittings. Sizes from ¼" to 2½" meet all locomotive and equipment requirements. Special high temperature hose types also available.

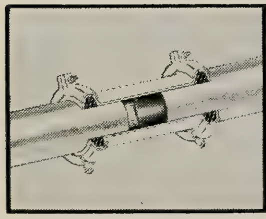
For Air Brake and Signal Lines, use Aeroquip 1531 Air Hose and Fittings. Hose has internal reinforcement for longer service life, lower initial cost.

Aeroquip
REG. TRADEMARK

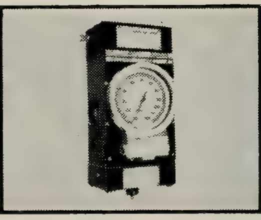
PRI
MEMBER

AEROQUIP CORPORATION • JACKSON, MICHIGAN
INDUSTRIAL DIVISION
INDUSTRIAL PLANTS: VAN WERT, O.; BURBANK, CALIF.; DALLAS, TEX.; PORTLAND, ORE.; CRANBURY, N.J.; ATLANTA, GA.
In Canada: Aeroquip (Canada) Ltd., Toronto 19, Ontario
In Germany: Aeroquip G.m.b.H., Baden Baden-Oos
AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A., CANADA AND ABROAD
FLEXMASTER is an Aeroquip Trademark

AEROQUIP PRODUCTS ARE DESIGNED FOR BETTER RAILROADING



FLEXMASTER Pipe Coupling



Barco Railroad Diesel Speed Recorder

Only Aeroquip offers two automatic diesel fueling systems

with America's most complete line of special trackwork: For Railroads, Mines and Industries—A complete line of *frogs, switches* and *crossings* • *Trackwork for installation in paved areas* • *Manganese steel guard rails* • *Automatic switch stands* • *Samson switch points* • *Snow-Blowers* • *Switch point guards* • *Rail and flange lubricators* • *Tie pads* • *Racor studs* • *Dual spike setters* • *Dual spike drivers* • *Car retarders.*

with America's most complete trackwork manufacturing facilities: Coast to coast to serve your needs.

⚑ **RACOR PLANTS:**
Buffalo • Chicago Heights • Los Angeles • Niagara Falls, Ontario, Canada • Pueblo • Superior.

★ **RACOR SALES AND ENGINEERING**
Chicago • Cleveland • Denver • Houston • Los Angeles • Louisville • New York • Philadelphia • Richmond • San Francisco St. Louis • St. Paul. In Canada: Dominion Brake Shoe Co., Ltd., Montreal, Quebec • Niagara Falls, Ontario • Winnipeg, Manitoba • Vancouver, B. C.

✱ **RACOR RESEARCH:**
Chicago • Mahwah, N. J.

with America's most complete trackwork engineering service: This lies in making available to our customers Racor's engineering experience—*practical* experience from years of designing and manufacturing . . . *advanced* experience solving tomorrow's trackwork problems today in Racor research laboratories.

Why not let us help *you* with your trackwork problems?

A-1646

RACOR

RAILROAD PRODUCTS DIVISION
530 Fifth Avenue, New York 36, New York

AMERICAN Brake Shoe COMPANY

Extend Tie Life!

Hold Gage!

USE TIE PLATE
LOCK SPIKES

One-piece Design

LOCK SPIKES hold tie plates firmly in place on cross-ties and bridge timbers.

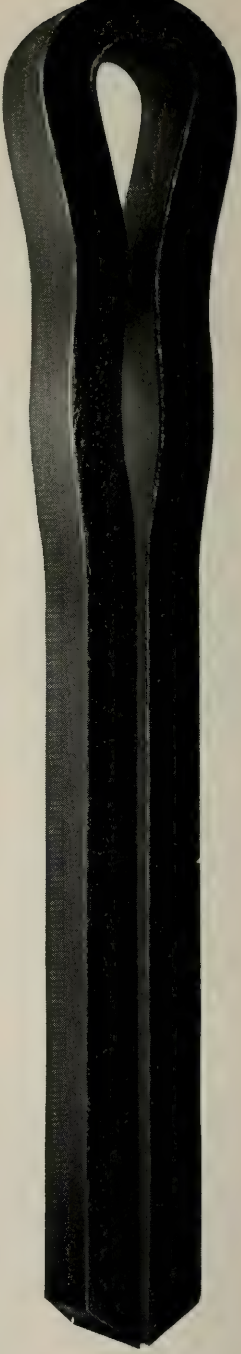
LOCK SPIKES are quickly and easily driven, or removed, *with standard track tools.*

Driven to refusal, the spread shank is compressed by the walls of the hole. Tie plates are held against horizontal and vertical movement under spring pressure. Play between the spike and the hole is eliminated—abrasion and seating of tie plates is overcome.

LOCK SPIKES hold their position in the tie, and redriving to tighten the plate is not required. They provide a quiet and strengthened track.

Annual cost of ties and maintenance expense is reduced by extending the life of ties and holding gage. Here is one answer to conservation of materials and labor. Write for free folder.

BERNUTH, LEMBCKE CO., INC.
420 Lexington Avenue, New York 17, N. Y.



Actual Size

PROTECTIVE COATINGS

Brooks coatings have proven to be superior in the protection of railroad splice bars and rail joints under severe conditions such as rails subjected to refrigerator car brine drippage and coastal salt water spray. These products have a low cold test for application by spray, pour or brush.

Brooks coatings are used to protect railroad bridge and trestle members as well as structural and steel tanks.

These petroleum base products, black in color, are compounded to resist and retard corrosion to metal surfaces. Four different coatings are available and require a minimum of surface preparation for application.

The BROOKS OIL Company

Established 1876

General offices and U.S. plant: 3304 East 87th Street • Cleveland 27 Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton Ontario

A COMPLETE LINE
OF SPRING WASHERS

THE NATIONAL LOCK WASHER CO.
Newark N. J., U. S. A.

NEW and RELAYING

RAIL
Switch Material · Tools
Track Accessories

PILING
Rental Steel-Sheet Piling
Pipe Pile · H-Bearing Pile

PIPE
Tested and Structural
All Sizes 1/8" thru 48"
Valves, Fittings, Flanges

*Immediate delivery
from Foster's nationwide
warehouse stocks.*

Specialists to the Railroads

L. B. FOSTER CO.

Pittsburgh
Cleveland
Los Angeles
San Francisco
Atlanta
New York
Chicago
Detroit
Houston
Orlando

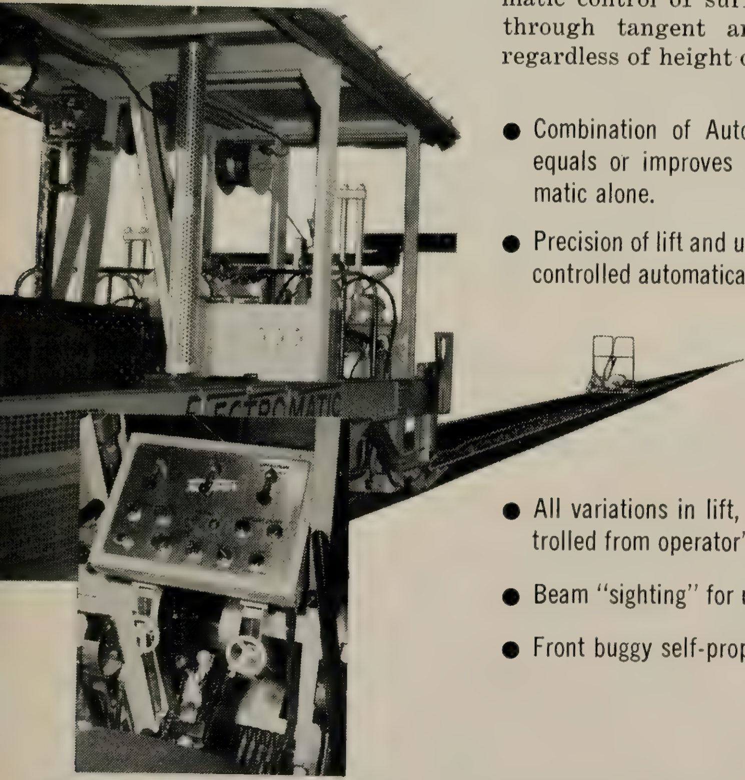
Tamper

AUTOJACK ELECTROMATIC

The only completely automatic track surfacing machine on the market

Proven in operation by North America's leading railroads. Complete and automatic control of surface and cross level through tangent and curve territory regardless of height of lift.

- Combination of Autojack and Electromatic equals or improves production of Electromatic alone.
- Precision of lift and uniformity of compaction controlled automatically.



- All variations in lift, level and run-out controlled from operator's panel.
- Beam "sighting" for utmost precision.
- Front buggy self-propelled ahead of tamper.

Tamper

TAMPER INC. 53 Court St., Plattsburgh, N.Y.
SALES AND SERVICE: 2147 University Avenue
St. Paul 14, Minnesota
Phone: 645-5055
IN CANADA 160 St. Joseph Blvd.,
Lachine (Montreal), P.Q.
Phone: 637-5531

Your enquiries for detailed information or brochures on Autojack Electromatic and other track machines are invited.

Hubbard Super Service Alloy Spring Washers
Hubbard Super Steel Alloy Spring Washers
Hubbard Track Tools

Hubbard Tool Division
UNIT RAIL ANCHOR CORPORATION
New York Pittsburgh Chicago

Unit Rail Anchor

UNIT RAIL ANCHOR DIVISION
UNIT RAIL ANCHOR CORPORATION
NEW YORK PITTSBURGH CHICAGO

P. O. Box 10378
Area Code 305
LOgan 6–7922

GREENHEART, INC.
1431 N. E. 26th Street
FORT LAUDERDALE, FLORIDA

President—John L. McEwen—Quarter Century Experience

IMPORTERS:
GREENHEART—3300F Piles, Lumber, Timbers Long Length
MORA EXCELSA—Lumber and Timbers
MANBARKLAK—Piles
ANGELIQUE (Basra Locus)—Piles, Lumber and Timbers
and other Woods from
Burma, Siam, Australia, Africa and South America
Data furnished on request

3279

IT'S GRS

CYB-O-MATIC

GRS systems engineering weds cybernetics with automatic operation—the result, CYB-O-MATIC.

A typical example, this ore train is moving at a slow, *steady* speed of ⅛ mph while being loaded from above. The load builds up sharply as the fourteen 100-ton capacity cars are loaded—but CYB-O-MATIC control keeps the pace steady.

Mechanoelectric — and electronic — systems substitute for human brains and nervous systems. Operation is entirely automatic. The resultant control is more uniform, more precise than even the most skillful manual control.

This is one example of CYB-O-MATIC control in revenue producing action. Expect more from GRS.

GENERAL RAILWAY SIGNAL COMPANY
A UNIT OF GENERAL SIGNAL CORPORATION

ROCHESTER, N. Y. 14602 NEW YORK, N. Y. 10017 CHICAGO, ILL. 60601 ST. LOUIS, MO. 63101 MONTREAL 2, P. Q.

Assure lower maintenance costs,
better performance with...

TEXACO
Petroleum Products and Systematic Engineering Service

TEXACO
TEXACO INC.
RAILWAY SALES DIVISION
135 East 42nd St., New York 17, N. Y.

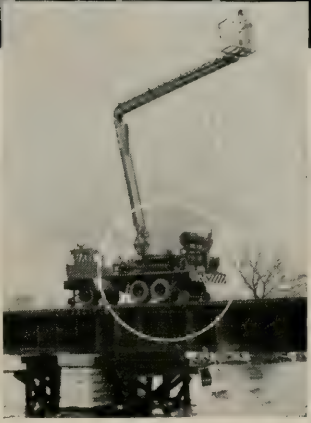
NEW YORK • CHICAGO • SAN FRANCISCO • ST. LOUIS • ST. PAUL • ATLANTA

THE DOUBLE U RAIL ANCHOR

ACHUFF RAILWAY SUPPLY CO.
ST. LOUIS, MO.

Get any coating job done... ANYWHERE with

GRACO HYDRA-SPRAY



The custom-built assembly shown above and to the right is an all-purpose rig designed to give *maximum* flexibility in coating and painting work. It was designed for field application of paints, lacquers, vinyls, cutback asphalts, creosotes, heavy oils and greases.

It uses the *economical* Graco Hydra-Spray Process, and proves once again, you get the job done faster and better with Graco than with any other coating system.

If speed of coating application, and material savings are important to you, write today for all the details of the Graco Hydra-Spray Process.

FREE! Graco Engineers are prepared to help you in the design of your paint and material spray assemblies. Your Graco Railway Representative will be glad to explain the many benefits of this service. Write or call him . . . *today!*

GRACO

RAILWAY DEPARTMENT

GRAY COMPANY, INC.
MINNEAPOLIS 13, MINNESOTA

JOHN P. McADAMS, Eastern Sales Representative
2304 Wilson Boulevard, Arlington, Virginia

CHICAGO—(Broadview, Ill.)
R. D. Worley
3030 South 25th Ave.

CLEVELAND
M. H. Frank Company, Inc.
1202 Marshall Building

HOUSTON
Houston Railroad Supply Co.
1610 Dumble Street

PHILADELPHIA
The A. R. Kidd Co.
1036 Suburban Station Bldg.

LOUISVILLE
T. F. & H. H. Going
6308 Limewood Circle

ST. LOUIS
The Carriers Supply Company
818 Olive Street

NEW YORK—Newark, New Jersey
R. A. Corley
744 Broad Street

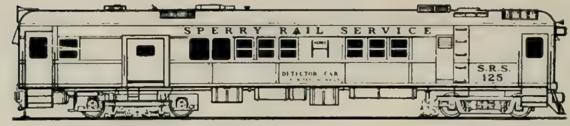
SAN FRANCISCO
The Barnes Supply Company
141 Eleventh Street

TWIN CITIES—St. Paul, Minn.
The Daniel L. O'Brien Supply Company
Endicott-On-Fourth Bldg.

WASHINGTON—Arlington, Va.
Southeastern Railway Supply, Inc.
2304 Wilson Blvd.

MONTREAL—Ontario, Canada
International Equipment Co., Ltd.
360 St. James Street West

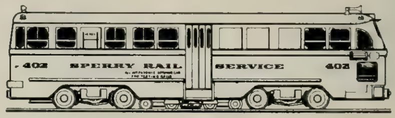
"FIRST IN RAIL TESTING"



INDUCTION-ULTRASONIC CAR

THE FLEET

Induction - Ultrasonic Cars	-14
Ultrasonic Cars - - - -	-14
All Ultrasonic (402) - - -	1
Research & Development -	1



ALL ULTRASONIC CAR 402

HOWE SOUND

SPERRY RAIL SERVICE

DIVISION OF HOWE SOUND COMPANY

General Offices DANBURY, CONN.

WOODINGS-VERONA TOOL WORKS

Pioneer Manufacturers

of

HIGH GRADE TRACK TOOLS

and

SPRING WASHERS FOR TRACK

Since 1873

VERONA, PA. CHICAGO, ILL.

W F T & Co

WOODINGS FORGE & TOOL COMPANY

Makers

of

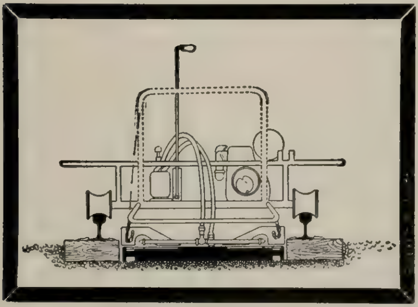
WOODINGS RAIL ANCHORS

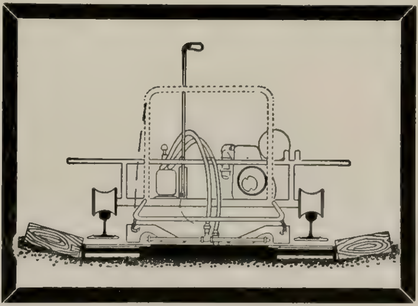
VERONA, PA. CHICAGO, ILL.

Model N U Tie Cutter

HERE IS THE WINNING TEAM

The Woolery NU Tie Cutter and the Woolery Tie-end Remover preserve the line and surface of the track and at the same time reduce the cost of tie renewals. Ties can be removed without trenching, jacking up track or adzing tops of rail-cut ties. With this team you simply cut both ends of tie, pry out center piece, insert in its place the tie-end remover and out go the tie ends pushed by the double acting, double ended hydraulic cylinder of the Tie-end remover.





FOR HIGHEST EFFICIENCY USE TWO TIE CUTTERS WITH ONE TIE-END REMOVER

WOOLERY MACHINE COMPANY

MINNEAPOLIS, MINN.

P. & M. PRODUCTS

- IMPROVED FAIR Rail Anchors

RAIL JOINT PRODUCTS

- Rajo Joints
- Insulated Joints
- Compromise Joints
- Fibre

MAINTENANCE EQUIPMENT PRODUCTS

- Meco Rail and Flange Lubricators
- Meco Rail Layers
- Meco Brush Cutters
- MACK Reversible Switch Point Protectors

PEERLESS EQUIPMENT PRODUCTS

- Draft Gears
- Rail Titan Batteries

IN CANADA:
The P. & M. Company Ltd.

552AB

PRODUCTS OF PROGRESS

POOR & COMPANY
Railway Products Division 80 E. Jackson Blvd., Chicago 4, Ill.

Notes on

Railroad Location and Construction Procedures from the School of Experience

By J. A. Given

A series of notes, comments, short-cut methods and "tricks of the trade" written by a railroad location engineer of many years of practical experience for the benefit of young engineers.

Price $0.50

AMERICAN RAILWAY ENGINEERING ASSOCIATION
59 East Van Buren Street
Chicago 5, Ill.

A NEW SYMBOL YOU'LL SEE ON THE MOST ADVANCED AUTOMATED TAMPERS

It's the newest, most thoroughly engineered, most efficient automated tamping equipment ever offered. These are the machines you have been waiting for, because behind them stands the experience and leadership of Jackson Vibrators, Inc. . . . the uncompromising standards of design, engineering, quality control and field service that you've relied on for more than half a century. This trade-mark is new . . . but what it stands for is as old as the Jackson name. Whether it is on the new automated maintainers or conventional track tamping equipment, it is your assurance of the highest integrity, the most practical designing and engineering, and the most comprehensive service to users available to railroad maintenance men throughout the nation. This is the new "Symbol" of progress in railroad maintenance. Be sure you get complete information concerning the new automated Jackson, and "automation conversion" package for earlier models of the Jackson Track Maintainer before purchasing any new tamping equipment.

JACKSON VIBRATORS, INC.
LUDINGTON, MICHIGAN, USA

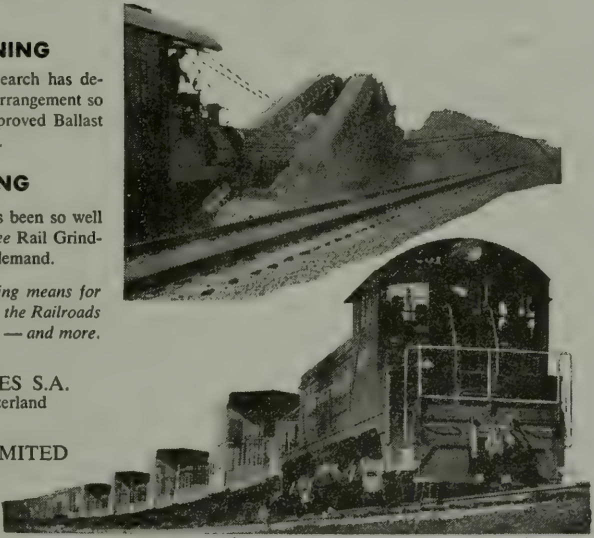
grip *is what a Channeloc® rail anchor is forged to do. Grip and hold. And still have plenty of reserve strength for reapplication. Plus—our particular way with steel gives Channeloc the temper, the spring, to adjust itself to rail-base variations—no shims. These days, Class 1 roads buy Channeloc by the million. Yours? True Temper, Railway Appliance Division, 1623 Euclid Avenue, Cleveland 15, O.*

TRUE TEMPER®
CHANNELOC® RAIL ANCHOR

PROGRESS REPORT

SPENO

Here are the up-to-date facts on the SPENO Ballast Cleaning and the SPENO Rail Grinding Services.



BALLAST CLEANING

SPENO Engineering and Research has developed a superior screening arrangement so that we are now using an improved Ballast Cleaner with greater efficiency.

RAIL GRINDING

Our Rail Grinding Service has been so well received — we now have *Three* Rail Grinding Trains to take care of the demand.

SPENO is constantly developing means for better service to make sure that the Railroads receive everything they pay for — and more.

Outside North American continent:

SPEMA RAIL SERVICES S.A.
Grand-Pont 2, Lausanne, Switzerland

Canadian Sales Representatives:

THE HOLDEN CO. LIMITED
614 St. James St., West
Montreal, Canada

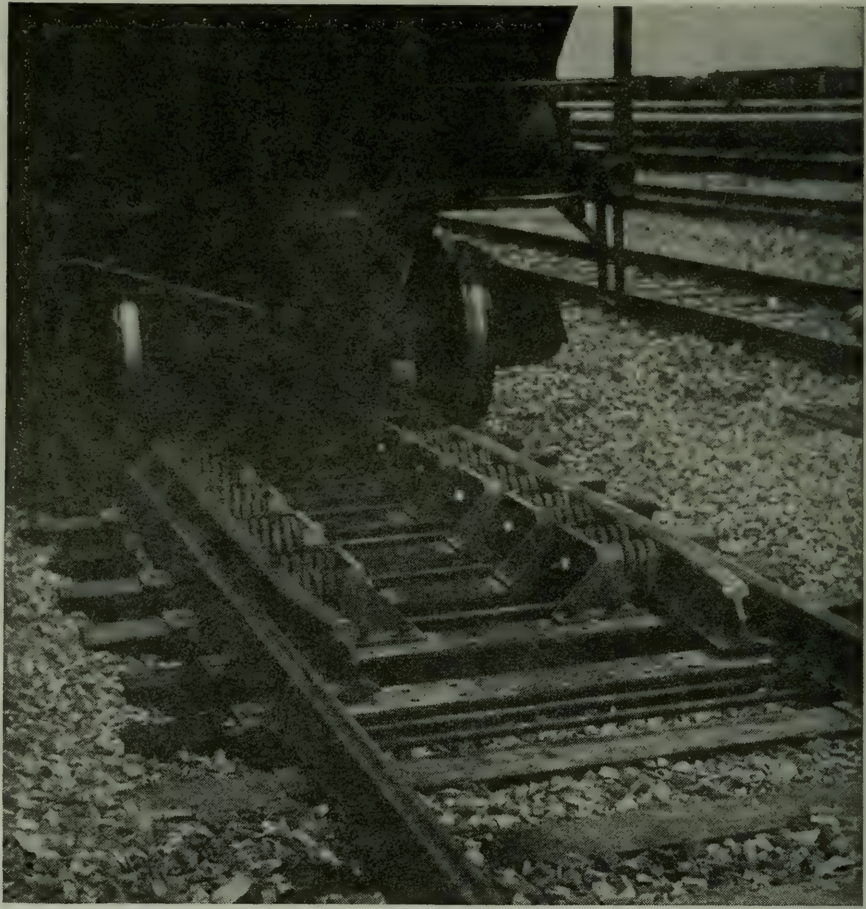
Just Ask the Railroads That have used us!

P R I
MEMBER

FRANK SPENO RAILROAD BALLAST CLEANING CO., INC.

Clark Street
East Syracuse, N. Y.

306 North Cayuga St.
Ithaca, N. Y.



THE TRASCO CAR RETARDER

HUNDREDS IN SERVICE
IN CLASS YARD TRACK

TRACK SPECIALTIES COMPANY
P.O. BOX 729 WESTPORT, CONNECTICUT

AMERICAN RAILWAY ENGINEERING ASSOCIATION, FOUNDED 1899

American Railway Engineering Association—Bulletin

Bulletin 588
Proceedings Vol. 66*

November 1964

REPORTS OF COMMITTEES

9—Highways -- 89
13—Water, Oil and Sanitation Services -------------- 99
14—Yards and Terminals ---------------------------- 127
16—Economics of Railway Location and Operation ---- 143
20—Contract Forms --------------------------------- 153
25—Waterways and Harbors -------------------------- 167
30—Impact and Bridge Stresses --------------------- 183

The reports in this issue of the Bulletin will be presented to the 1965 Annual Meeting of the Association at McCormick Place, Chicago, March 23–25. Comments and discussion with respect to any of the reports are solicited, and should be addressed to the chairman of the committee involved, in writing in advance of the Meeting, or from the floor during the Meeting.

---

* The contents of this Bulletin and the other Bulletins of the Association from Bulletin 587, September–October 1964, to and including Bulletin 593, June–July 1965 (except Bulletin 592, March 1965), will constitute the Annual Proceedings of the Association, Vol. 66.

Copyright 1964, by American Railway Engineering Association

BOARD OF DIRECTION

1964–1965

President

T. F. Burris, Special Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

Vice Presidents

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.

J. M. Trissal, Vice President, Illinois Central Railroad; Vice President—Development, Illinois Central Industries, Chicago, Ill. 60605

Past Presidents

C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania Railroad, Philadelphia, Pa. 19104

L. A. Loggins, Chief Engineer, Southern Pacific Company, Texas and Louisiana Lines, Houston, Tex. 77001

Directors

W. L. Young, Resident Vice President, Norfolk & Western Railway, Roanoke, Va.

T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va. 23213

C. E. Defendorf, Chief Engineer, New York Central System, New York, N. Y. 10017

John Ayer, Jr., Vice President—Operations, Denver & Rio Grande Western Railroad, Denver, Colo. 80217

A. L. Sams, Chief Engineer, Illinois Central Railroad, Chicago, Ill. 60605

D. C. Hastings, Assistant Vice President—Operations, Atlantic Coast Line Railroad, Jacksonville, Fla. 32202

B. B. Lewis, Professor of Railway Engineering, Purdue University, Lafayette, Ind.

H. M. Williamson, Chief Engineer System, Southern Pacific Company, San Francisco, Calif. 94105

H. E. Wilson, Assistant Chief Engineer—System, Atchison, Topeka & Santa Fe Railway, Chicago, Ill. 60604

J. S. Parsons, Erie–Lackawanna Railroad, Cleveland, Ohio. 44115

S. H. Poore, Office Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

F. N. Beighley, Roadway Engineer, St. Louis–San Francisco Railway, Springfield, Mo. 65801

Treasurer

A. B. Hillman, Retired Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago.

Executive Secretary

Earl W. Hodgkins, 59 East Van Buren Street, Chicago, Ill. 60605

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Street, Chicago, Ill. 60605

Published by the American Railway Engineering Association, Monthly, January, February, March, November and December; Bi-Monthly, June-July, and September-October, at 2211 Fordem Avenue, Madison, Wis.; Editorial and Executive Offices,
59 Van Buren Street, Chicago 5, Ill.
Second class postage paid at Madison, Wis.
Accepted for mailing at special rate of postage for in Section 1103, Act of October 3, 1917, authorized on June 29, 1918.
Subscription $10 per annum.

Report of Committee 9—Highways

R. W. Mauer, *Chairman*

R. Dejaiffe,
Vice Chairman

R. E. Skinner, *Secretary*

E. R. Englert
T. C. Netherton
J. A. Jorlett
C. A. Christensen
C. W. Traister
C. I. Hartsell
W. S. Autrey
F. N. Barker
H. J. Barnes
G. B. Blatt
W. A. Buckmaster
F. C. Cunningham
T. P. Cunningham
F. Daugherty
Wm. J. Hedley
J. T. Hoelzer
J. A. Holmes
W. H. Huffman
R. F. MacDonald
C. B. May
H. L. Michael

E. S. Miller
D. J. Moody
H. G. Morgan (E)
R. E. Nottingham (E)
K. Ovardits
R. K. Pattison
W. C. Pinschmidt (E)
J. E. Reynolds
P. H. Slack
J. E. Spangler
R. F. Spars
R. W. Summerford
J. M. Trissal
H. W. Walbright
V. R. Walling (E)
G. H. Way, Jr.
H. J. Wilkins
M. A. Wohlschlaeger
H. L. Woltman
K. E. Wyckoff
Committee

(E) Member Emeritus.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 9.

To the American Railway Engineering Association

Your committee reports on the following subjects:

1. Revision of Manual.
Progress report, submitted for adoption .... page 90

2. Merits and economics of prefabricated types of highway–railway grade crossings.
Brief status report .... page 93

3. Merits of various types of highway–railway grade crossing protection, collaborating with Communication and Signal Section, AAR.
Brief progress report, submitted as information .... page 93

5. Extent of use and effectiveness of highway-type stop signs at highway–railway grade crossings.
Progress report, submitted as information .... page 94

6. Methods of providing additional advance warning to highway traffic approaching a highway–railway grade crossing.
Brief progress report, submitted as information .... page 96

7. Conduct study with the view toward developing alternate types of automatic crossing protection, collaborating with Communication and Signal Section, AAR.
   Report on special signal, submitted as information .... page 96

THE COMMITTEE ON HIGHWAYS,
R. W. MAUER, *Chairman*.

AREA Bulletin 588, November 1964.

Report on Assignment 1

Revision of Manual

E. R. Englert (chairman, subcommittee), W. S. Autrey, G. B. Blatt, F. C. Cunningham, F. Daugherty, J. T. Hoelzer, W. H. Huffman, J. A. Jorlett, H. L. Michael, R. E. Nottingham, R. K. Pattison, W. C. Pinschmidt, R. E. Skinner, K. E. Smith, R. W. Summerford, C. W. Traister, H. W. Walbright, H. J. Wilkins, M. A. Wohlschlaeger, K. E. Wyckoff.

In March of 1963, your committee reported that a letter ballot had been approved for submittal to the committee membership calling for the elimination from the Manual of the 6-ft 50-deg type of highway crossing sign. The ballot was sent out and there were no dissenting votes. Since that time another ballot was submitted to the committee membership calling for the elimination of the wig-wag type of signal from the Manual. Included in this ballot were provisions for the use of "saving clauses" recommended by the AAR Law Department to protect those railroads still having the wig-wag type of signal in operation. This ballot has also received approval of your committee with no dissenting votes.

The Manual changes approved by your committee are now submitted for adoption by the Association. The specific changes are as follows:

Page 9–2–1

RECOMMENDED USE OF HIGHWAY–RAILWAY GRADE CROSSING SIGNS

In the table, delete Crossing Situations 1, 2 and 4, including the data pertaining thereto under the column headings "Sign Recommended" and "AREA Manual Reference Pages."

Change Situation 3 under the heading "Crossing Situation" to read as follows:

3. "At crossings where an indication of the location of a railroad is considered to be sufficient, with or without improved night indication."

Change Situation 3 under the heading "Sign Recommended" to read as follows:

3. "Reflector-type or painted 4-ft blades of suitable material at 90-deg angle on post at side of roadway. Reflecting medium may be enclosed lens, reflective sheeting or reflector buttons."

Change Situation 5 under the heading "Sign Recommended" to read as follows:

5. "Crossbuck sign listed above, together with 'WATCHMAN OFF DUTY' sign . . ."

Change Situation 6 under the heading "Sign Recommended" to read as follows:

6. "Crossbuck sign listed above, together with 'GATES NOT WORKING' sign . . ."

Change the "AREA Manual Reference Pages" for Situation 5 to 9–2–4, 9–2–6, 9–2–8, 9–2–9.

Change the "AREA Manual Reference Pages" for Situation 6 to 9–2–4, 9–2–7, 9–2–8, 9–2–9.

Eliminate "Note" at the bottom of the table and substitute the following:

Note—The practices contained in Part 2 of Chapter 9 of the Manual are recommended for new installations or when general replacement of present apparatus is to be made. State or provincial laws will govern where there are differences in requirements from any of these recommendations.

These recommendations are in the interest of establishing uniformity in traffic control and safety devices at railroad–highway crossings, and they do not, in any way, imply or otherwise suggest inadequacy of installations which may not conform to the provisions of this Manual.

Page 9–2–2

Fig. 1—Highway Crossing Sign, Painted, 6-Ft, 50-Deg Type

Delete.

Page 9–2–3

Fig. 2—Highway Crossing Sign, Reflector, 6-Ft, 50-Deg Type

Delete.

Page 9–2–4

Fig. 3—Highway Crossing Sign, Painted, 4-Ft, 90-Deg Type

Change title to read: Highway Crossing Sign—Reflector or Painted, 4-Ft, 90-Deg Type.

Delete all notes and substitute the following notes:

> All letters and numerals to be in black color on white background, either reflectorized or painted.
>
> Locate signs at such points as will admit of the best view by persons approaching the crossing.
>
> Height may be varied as required by local conditions.
>
> Signs indicating number of tracks to be used where there are two or more tracks. The number displayed on the sign shall be total number of tracks crossed, including sidings. Where number and letters of this sign are outlined using reflector buttons, a black background may be used.
>
> The distance that shall be assumed to separate tracks before an additional crossing sign is considered is 100 ft, unless local conditions require otherwise.
>
> All or any part of sign may be constructed of wood or metal, mounted on wood, metal or concrete post.
>
> The plan shows the crossing sign mounted on a wood post. Where a post of metal or concrete is used, the dimensions of the post shall be suitable to the material employed.

Page 9–2–5

Fig. 4—Highway Crossing Sign, Reflector, 4-Ft, 90-Deg Type

Delete.

Page 9–3–1

RECOMMENDED USE OF HIGHWAY–RAILWAY GRADE CROSSING SIGNALS

For the crossing situation "At single-track crossings," eliminate the reference to "wig-wag signal" under "Signal Recommended" and the page numbers for this signal (9–3–19 and 9–3–20, incl.) under "AREA Manual Reference Pages."

For the crossing situation "At multiple-track crossings," where the signal recommended is "Same as for single-track crossings, or" change the AREA Manual Reference Pages to read 9–3–2 to 9–3–18, incl.

Delete "Note" at the bottom of the table and substitute the following:

Note—The practices contained in Part 3 of Chapter 9 of the Manual are recommended for new installations or when general replacement of present apparatus is to be made. State or provincial laws will govern where there are differences in requirements from any of these recommendations.

These recommendations are in the interest of establishing uniformity in traffic control and safety devices at railroad–highway crossings, and they do not, in any way, imply or otherwise suggest inadequacy of installations which may not conform to the provisions of this Manual.

Pages 9–3–2 and 9–3–3

SPECIFICATIONS FOR HIGHWAY GRADE CROSSING SIGNALS

Page 9–3–2, Art. 2—Aspect. In line 3 delete reference to Fig. 16 and Fig. 17. In line 5 delete the words "or swinging disk."

Art. 2—Mounting. Delete paragraph (a) and redesignate paragraph (b) as paragraph (a).

Art. 4—Painting. In paragraph (a) delete the first two words, "Disks and." Also delete references to AAR Signal Drawings 1553, 1640, 1644, 1648.

Page 9–3–3. Delete the boldface heading "Wig-Wag Type" between Arts. 9 and 10, and delete Arts. 10, 11, 12, and 13 in their entirety.

Page 9–3–19

Fig. 16—Highway Crossing Signal, Wig-Wag Type with Stop When Swinging Sign

Delete.

Page 9–3–20

Fig. 17—Highway Crossing Signal, Wig-Wag Type with Stop Sign

Delete.

Pages 9–4–1 and 9–4–2

SPECIFICATIONS FOR AUTOMATIC CROSSING GATES

Page 9–4–1, Art. 2—Mounting. In line 1 delete the words: "or wig-wag type signal."

Report on Assignment 2

Merits and Economics of Prefabricated Types of Highway–Railway Grade Crossings

T. C. Netherton (chairman, subcommittee), W. S. Autrey, H. J. Barnes, W. A. Buckmaster, T. P. Cunningham, F. Daugherty, E. R. Englert, J. T. Hoelzer, W. H. Huffman, C. B. May, E. S. Miller, D. J. Moody, R. E. Nottingham, R. K. Pattison, P. H. Slack, R. W. Summerford, C. W. Traister, H. W. Walbright, G. H. Way, Jr., H. J. Wilkins, M. A. Wohlschlaeger.

For a number of years your committee has been accumulating information in regard to the merits and economics of prefabricated types of grade crossing materials. This information became the basis of our report to the Association in March 1964.

We have found that it is very difficult, if not impossible, to give a reliable dollar value to the costs of installation and maintenance for comparing the economics of the various types of grade crossing materials. However, we feel that this is an important subject and that we should continue our investigations, especially in regard to the rubber-panel-type crossing.

This is a status report, submitted as information, and your committee recommends that the subject be continued.

Report on Assignment 3

Merits of Various Types of Highway–Railway Grade Crossing Protection

Collaborating with Communication and Signal Section, AAR

J. A. Jorlett (chairman, subcommittee), H. J. Barnes, G. B. Blatt, C. A. Christensen, R. Dejaiffe, E. R. Englert, Wm. J. Hedley, J. T. Hoelzer, J. A. Holmes, W. H. Huffman, C. B. May, H. L. Michael, D. J. Moody, R. E. Nottingham, K. Ovardits, R. E. Skinner, P. H. Slack, J. E. Spangler, R. F. Spars, H. W. Walbright, G. H. Way, Jr., H. J. Wilkins, M. A. Wohlschlaeger, H. L. Woltman, K. E. Wyckoff.

Activity on this assignment has been restrained because two other organizations have programmed activities which promise to be of special significance in the matter of highway–railway grade crossing protection.

Funds have been provided in past years by the Research Department of the Association of American Railroads to finance Committee 9 sponsored studies by the Armour Research Foundation of the Illinois Institute of Technology of train and motor-vehicle accidents occurring at highway–railway grade crossings in the State of Iowa on a single railroad and in the State of Ohio on all railroads. We were cautiously seeking for a scientific resolution of various factors and characteristics of highway–railway grade crossings that could be used in conjunction with high-speed electronic computers to derive a formula for determining hazard indices for crossings with various types of warning devices.

The Bureau of Public Roads has used rating indices of empirical origin to determine priorities for improving crossing protection or separation of grades. Last year we reported that under its National Cooperative Highway Research Program the Bureau had commissioned the Highway Research Board at the National Academy of Sciences—National Research Council, Washington, D. C., to undertake a study of "Factors Influencing Safety at Highway–Rail Grade Crossings." This study is under way by Alan M. Voorhees, consulting engineers, Washington. The work scope of Objective 1 of the study is (a) to make a résumé of previous research directed to crossing accident prediction and crossing protection, and (b) an assembly and analysis of available data of current relevance to the problem. Objective 2 is to develop an experimental design for further research into crossing accident prediction, giving consideration to mass statistical analyses and/or case studies. We are awaiting the consultant's report for our investigation.

The second important activity relating to our assignment is the action taken by the AAR to deal with Recommendations Nos. 6 and 7 prescribed by the ICC in Docket 33440, "Prevention of Rail–Highway Grade–Crossing Accidents." These appeared verbatim in the March 1964 progress report for Assignment 3. A Joint Committee is to be set up with representatives of the Engineering Division, AAR; TOC&S; the AAR Grade Crossing Committee and the Law Department of AAR to consider these ICC recommendations and to develop suggestions as to how the railroad industry might implement them.

The ICC investigation has done much to strengthen the premise that the railroads are no longer the prime instrument of danger and the main cause of accidents at highway–railway grade crossings. Paragraph No. 13 of the findings in the Docket states:

> "Highway users are the principal recipients of the benefits flowing from rail–highway grade separations and from special protection at rail–highway grade crossings. For this reason the cost of installing and maintaining such separations and protective devices is a public responsibility and should be financed with public funds the same as highway traffic devices."

Committee 9 believes that its work on this assignment will be useful to the Joint Committee and the local, state and federal authorities concerned with this problem.

This is a progress report submitted as information. Your committee recommends that the assignment be continued.

Report on Assignment 5

Extent of Use and Effectiveness of Highway-Type Stop Signs at Highway–Railway Grade Crossings

C. A. Christensen (chairman, subcommittee), F. N. Barker, H. J. Barnes, W. A. Buckmaster, F. C. Cunningham, T. P. Cunningham, F. Daugherty, R. Dejaiffe, C. I. Hartsell, Wm. J. Hedley, J. A. Holmes, R. F. MacDonald, C. B. May, H. L. Michael, E. S. Miller, T. C. Netherton, K. Ovardits, J. E. Reynolds, J. E. Spangler, R. F. Spars, R. E. Skinner, J. M. Trissal, H. J. Wilkins, M. A. Wohlschlaeger, H. L. Woltman, K. E. Wyckoff.

Your committee submits the following report of progress in the gathering of information relating to the use and effectiveness of highway-type stop signs at highway–railway grade crossings.

The City of Rolla, Mo., is located some 110 miles southwest of St. Louis on the main line of the St. Louis–San Francisco Railway. It has a population of approximately 11,000, which figure is swelled to approximately 15,000 during the normal school terms of the University of Missouri at Rolla. The Frisco bisects the city, its single main track running in an approximate north-south direction. In the heart of the city the line is located approximately one block east of the main north-south thoroughfare. There are eight crossings within the city limits of Rolla, three of which are protected with automatic flasher-light signals. The remaining five crossings are protected with cross-buck signs.

Following a series of train-auto accidents at the crossings in town, the city council passed an ordinance in January 1962 requiring motorists to stop at railroad crossings. Stop signs of the conventional boulevard type were installed at all crossings. Additionally, there was installed a 12- by 24-in metal sign immediately below the octagonal sign, with a two-line message in red letters 4 in high, with a ¾-in-stroke, on silver reflective background, reading "AT R.R. CROSSINGS."

Members of your committee have visited Rolla to observe the behavior of motorists at the crossings, particularly the three most heavily traveled crossings in mid-town where the flashers are located. At the first visit in August 1962, when the law had been in effect about seven months, it was observed that about 35 percent of the motorists made complete stops—the majority making a so-called rolling stop. The stop sign was completely ignored by drivers of 5 percent of the private vehicles, but less than 1 percent of the commercial vehicle drivers made no stop.

In August 1963, when a second visit was made, it was observed that of the passenger vehicles only 36 percent came to a complete stop, while 42 percent of the commercial vehicles complied completely with the stop requirement. Total disregard of the stop sign was observed to be 27 percent for passenger vehicles and 3.5 percent for commercial vehicles.

A third visit was made in September 1964. It was then observed that 60 percent of the passenger vehicle drivers made a full stop, 35 percent made a rolling stop and 5 percent ignored the stop sign. Of the commercial vehicles, 66 percent made a full stop, 31 percent made a rolling stop and 3 percent made no stop whatever.

Interviews with the Chief of Police revealed that he is very pleased with the results obtained. Since the ordinance was passed, there have been no train-auto accidents. He advised that in the beginning it was necessary to issue many citations for violations. Fines were assessed as for violations of stop signs at street intersections. There were some objections, but with time the stopping at crossings became acceptable and the majority respect the requirement. Periodically, it is necessary to step up enforcement when signs of laxity appear. This is always done at the start of the fall term of school when new students arrive who are not familiar with the ordinance.

It is apparent that the passage of the ordinance and continuous policing to insure compliance have resulted in making the drivers alert to the dangers at crossings. Possibly Rolla, because of its size and arrangement of highways and streets, is better able to take advantage of this type of ordinance than would a larger city or one in which more traffic passes through the community; but in the case of Rolla, the ordinance does work. Your committee plans to extend its study to determine the extent of use of the stop sign in other communities.

This is a progress report, submitted as information, with the recommendation that the subject be continued.

Report on Assignment 6

Methods of Providing Additional Advance Warning to Highway Traffic Approaching a Highway-Railway Grade Crossing

C. W. Traister (chairman, subcommittee), W. S. Autrey, G. B. Blatt, W. A. Buckmaster, C. A. Christensen, F. C. Cunningham, R. Dejaiffe, C. I. Hartsell, J. A. Holmes, J. A. Jorlett, R. F. MacDonald, C. B. May, H. L. Michael, D. J. Moody, T. C. Netherton, K. Ovardits, R. K. Pattison, R. J. Pierce, W. C. Pinschmidt, J. E. Reynolds, J. E. Spangler, R. F. Spars, R. W. Summerford, H. L. Woltman.

Subsequent to the progress report of your committee published in Bulletin 581, November 1963, Vol. 65, page 173, a follow-up inquiry has been addressed to the chief administrative officers of all state highway departments. This supplement to our earlier approach inquired as to the latest appraisal of the effectiveness of certain special devices installed on the approaches to highway-railway grade crossings and requested information relating to the type, design, location and description of the signs or signals installed by the individual states since their last reply.

As soon as replies are received from all, or substantially all, the states, your committee will make an analysis of the information furnished and report its findings to the Association.

This is a progress report, submitted as information. Your committee recommends that the subject be continued.

Report on Assignment 7

Conduct Study with the View Toward Developing Alternate Types of Automatic Crossing Protection

Collaborating with Communication and Signal Section, AAR

C. I. Hartsell (chairman, subcommittee), F. N. Barker, G. B. Blatt, W. A. Buckmaster, C. A. Christensen, F. C. Cunningham, T. P. Cunningham, Wm. J. Hedley, J. T. Hoelzer, J. A. Holmes, J. A. Jorlett, R. F. MacDonald, E. S. Miller, K. Ovardits, J. E. Reynolds, R. E. Skinner, P. H. Slack, J. E. Spangler, R. F. Spars, C. W. Traister, H. W. Walbright, G. H. Way, Jr., H. L. Woltman, K. E. Wyckoff.

The Illinois Commerce Commission is sanctioning a special signal as a supplement to the standard flashing light signal to indicate the approach of a second train on a double main line in lieu of gates at some locations where gates would normally be considered necessary. This device consists of a separate signal mast on which two round, 14-in lenses are mounted, one above the other. Both lenses are aimed at a driver in a vehicle stopped for the standard flashing-light signal and are illuminated only upon the approach of a second train. The top lens on this signal reads "WAIT" in black letters and has a flashing red background. The lower lens reads "2 TRAINS" in black letters and has a flashing white background.

This type of installation has been used by a few western railroads and is presently being used by some midwestern railroads. However, they are too recent to have proved their value.

The following data, developed from the report of the Communication and Signal Section, AAR, are presented as information.

Grade Crossing Predictor

The grade crossing predictor, one of which is required for each approach, combines the functions of track circuits for detection, line circuits for varying length of control, and timing circuits for speed determination into one unit, which is placed at the crossing. A pair of insulated joints are required at or adjacent to the crossing. The predictor feeds a constant current signal to the track, and a receiver is used to sense the voltage developed across the track. A built-in computer circuit determines the rate of change of the received voltage and measures train speed. Train sped is then multiplied by warning time, and as soon as the computer senses the fact that the train speed and warning time required are proper, the relay actuates the crossing protection. A self-checking feature is built into the unit to check the components of the device at 4.5-sec intervals. If this self-checking pulse, which simulates a train exceeding any conventional operating speed, is not passed through the unit, the signal relay will be de-energized and will cause the crossing protection to operate.

These grade crossing predictors are in use on a number of railroads in various parts of the country with good results. The predictor can be most useful in areas where train speeds vary considerably, and timing circuits would be required for normal operation in order to limit excessive operation of the crossing protection. This unit can eliminate the special speed-measuring or timing circuits to determine train speeds, the line wire required to repeat such special track circuits to the crossing, and a large number of insulated joints.

Overlay Circuits

In essence, the overlay circuit is not intended to be more than the name implies—a separate and distinct track circuit with its own feed and relay capable of being overlaid, or superimposed, on the conventional track circuits and having the advantage of requiring no insulated joints. Where insulated joints are used for conventional track circuits, the joints must be bridged with band-pass filters if the overlay is to pass by.

The overlay equipment now available has receivers designed on a closed-circuit principle and can be used either for primary control of grade-crossing signals or as an adjunct to existing circuits to hold the track circuits required to a minimum and permit selection of several starts through use of the conventional timing circuits.

Several types of transmitters are available for this equipment, permitting the installation of overlay track circuits up to 4000 ft in length. In addition to the application of these devices as special adjuncts for release of electric locks and other local detection devices, control circuits for grade-crossing devices are now being installed, utilizing overlay equipment to minimize insulated joint requirements.

The overlay equipment will not replace or eliminate the need for timing circuits where it is necessary to regulate the operating time of the signal to the speed of the train.

This is a progress report, submitted as information. Your committee recommends that the subject be continued.

Report of Committee 13—Water, Oil and Sanitation Services

E. C. Harris, *Chairman*

T. A. Tennyson,
Vice Chairman

H. E. Graham, *Secretary*

J. J. Dwyer
C. F. Muelder
W. F. Arksey
F. O. Klemstine
E. R. Schlaf
V. C. Barth
T. L. Hendrix
W. C. Harsh
R. A. Bardwell
J. P. Rodger
R. C. Archambeault
R. C. Bardwell (E)*
J. M. Bates
W. E. Billingsley
T. W. Brown
P. J. Calza
C. E. DeGeer
D. E. Drake

A. E. Dulik
T. I. Gray
H. M. Hoffmeister
H. L. McMullin (E)
G. F. Metzdorf
P. M. Miller
E. T. Meyers
Henry Parrish, Jr.
A. B. Pierce (E)
R. D. Powrie
J. C. Roberts
H. E. Silcox (E)
D. C. Teal
H. W. Van Hovenberg (E)
C. B. Voitelle
E. M. Walters
J. E. Wiggins, Jr.
Committee

(E) Member Emeritus.
* Died June 7, 1964.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 13.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, with revisions submitted for adoption .... page 101

2. Prevention of corrosion in hot water heating systems.
   Final report, presented for adoption and publication in the Manual ..... page 104

3. Design, construction and operation of railroad sanitary and servicing facilities and relations with governmental agencies pertaining to these facilities.
   Progress report on current legislation pertaining to private wells and sewage disposal, and new literature on coach drinking water, presented as information .... page 107

4. Cathodic protection of pipelines and steel storage tanks, Collaborating with Committee 18.
   Final report, submitted for adoption and publication in the Manual ..... page 108

6. Railway waste disposal.
   The committee reports progress in its study of removing solids from waste water, but no report is submitted for publication this year.

7. Installation and maintenance of liquefied petroleum gas facilities.
   Progress report, submitted for adoption and publication in the Manual .. page 115

8. Methods of controlling spillage of fuel oil at diesel fueling and unloading stations.
   Progress report, submitted as information, on a study made by manufacturers' committee on standardization of automatic-shut-off diesel fueling facilities .... page 125

9. Disinfectants, deodorants, fumigants, and cleaning materials.
   Study is in progress on each phase of this subject, which is expected to be completed so that a final report can be submitted for publication in the Manual next year. No formal report is ready at this time.

10. Bacteria growth in diesel fuel, collaborating with Mechanical Division, AAR.
    No report. The committee expects to complete its study on this subject by next year.

11. Engine cooling water treatment.
    Because of the transfer of the subcommittee chairman to the West Coast, it was not possible for him to progress this subject during the past year. Study is to be resumed for a final report for next year.

12. Water for battery use.
    Specifications covering water quality for battery use submitted for adoption and publication in the Manual .... page 126

THE COMMITTEE ON WATER, OIL AND SANITATION SERVICES,
E. C. HARRIS, *Chairman.*

AREA Bulletin 588, November 1964.

MEMOIR

Robert Cousins Bardwell

Robert Cousins Bardwell, retired superintendent of water supply, Chesapeake & Ohio Railway, died at his home in Mount Dora, Fla., on June 7, 1964. He is survived by a daughter, Mrs. Claire Bardwell Debo, and two sons, R. C. Bardwell, Jr. of Mount Dora and R. A. Bardwell, engineer of tests, Southern Pacific Company, San Francisco, Calif. His wife preceded him in death in 1963.

Mr. Bardwell was born on January 1, 1888, at Tipton, Iowa, and received his technical education at the University of Illinois, graduating in June 1909 with a Bachelor of Arts Degree in Chemical Engineering.

His long and successful railroad career began on the Missouri Pacific where he served as chemist 1910–1916, assistant engineer 1916–1917, chief chemist 1917–1920, and engineer of water service until December 31, 1922, when he resigned to head the water production and chemical treatment department of the Chesapeake & Ohio with the title of superintendent of water supply, in which capacity he served with nation-wide distinction until his retirement on February 1, 1953.

Mr. Bardwell was very active and well known in the American Railway Engineering Association, of which he became a member in 1917, and was a director 1934–1936. He served on Committee 13, now known as the Committee on Water, Oil and Sanitation Services, continuously from 1918 to 1953, being vice chairman 1924–1930 and chairman 1931–1937. He was elected Member Emeritus in 1953.

He was also a member of Committee 21—Economics of Railway Operation, 1930–1934; Committee 26—Standardization, 1931–1937; the Special Committee on Clearances, 1931–1937, and the Emergency Committee on Fuel, Water and Sanitary Facilities, 1950–1953.

In addition, he was a member of the Association's Convention Arrangements Committee 1928–1953, and was chairman of that committee in 1931, 1934, and 1953. He became a Life Member of the Association in 1952 and an Honorary Member of the Arrangements Committee on December 20, 1954.

Mr. Bardwell will be long remembered by his many friends and associates, not only for his unusual capacity for railroad and Association work, but for his loyalty and helpfulness. The committee salutes an outstanding citizen, comrade and friend.

MEMOIR

Albert Willard Johnson

Albert Willard Johnson, retired steam heat and water engineer, Atchison, Topeka & Santa Fe Railway, died at his home in Boulder, Colo., on March 27, 1964.

Mr. Johnson was born in Topeka, Kan., on November 8, 1894. He received his education in engineering at the University of Kansas and studied law at Washburn University. His long and productive railroad career started in June 1911 in the Engineering Department of the Santa Fe where he served in various positions until his retirement in July 1962.

He became a member of the American Railway Engineering Association in 1932, serving on Committee 13—Water, Oil and Sanitation Services, from 1939 until his retirement. He gave generously of his time and talent to subcommittees on locomotive watering and fueling facilities, and was an outstanding chairman of subcommittees on design and construction of diesel fueling facilities from 1956 to 1960.

Mr. Johnson was held in high esteem by his many friends and associates, not only for his engineering ability, but also for his keen insight into human nature and his extraordinary sense of humor. He will be greatly missed.

Report on Assignment 1

Revision of Manual

T. A. Tennyson (chairman, subcommittee), W. F. Arksey, A. E. Dulik, T. L. Hendrix, F. O. Klemstine, C. B. Voitelle.

Your committee has continued its study of Chapter 13 of the Manual, giving particular attention to Part 9—Diesel Locomotive Fuel and Water Services, and now recommends the adoption of the following revisions of this part to bring it into line with best current practice:

Pages 13–9–1 to 13–9–14, incl.

DIESEL LOCOMOTIVE FUEL AND WATER SERVICE

Page 13–9–1. Add the following to Sec. A—Scope: "These facilities can be adapted to delivery of fuel by highway transport trucks by providing suitable access and connections for such vehicles. Figs. 2 and 3 show schematic arrangements for barge unloading facilities."

Insert new Figs. 2 and 3 (presented herewith) following Fig. 1 on page 13–9–2.

Page 13–9–1. Under Sec. A, Art. 2—Compliance with Governing Laws Regarding Approval of Plans, Etc., add the following under *Submission of Plans:* "Where fuel is to be unloaded from barges or other waterborne transportation, approval from the Corps of Engineers and Coast Guard may be necessary."

Page 13–9–4. Under Sec. B, Art. 4—Tank Appurtenances and Fixtures, add the following after the sentence under *Level Indicators:* "For delivery of oil by barge or common carrier pipeline, it is customary to base payments on actual tank measurements. Since storage tanks in this service are required to be strapped and gaged, gaging hatches are needed."

Under *Ladders* change the last sentence to read: "The alternate to the vertical ladders is a stair arrangement with handrail." Also, add the following sentence: "This arrangement is desirable where tanks are used to receive fuel from barges or common-carrier pipelines when frequent climbing of the tank is required for gaging purposes."

Add as the second sentence under *Vents:* "If existing facilities are used to receive fuel from a common-carrier pipeline, size of vents may have to be increased to accommodate the higher pumping rate usually encountered."

Page 13–9–5. Under Sec. C, Art. 1—Selection of Pump, change the first sentence under *Sizes* to read as follows: "Freight and passenger diesels are now equipped with fuel oil tanks that hold from 800 to 5000 gal, and future designs may have even larger tanks. These tanks are usually vented for a maximum delivery of around 300 gpm."

Page 13–9–6. Under Sec. C, Art. 3—Pumping Plant Appurtenances and Accessories, to correct a typographical error in the first sentence of *Electrical Facilities,* change the word "require" to "required."

Under *Meters,* add the following statement as the last sentence of the last paragraph: "When diesel fuel is delivered by highway transport trucks, it is desirable to have a printing-type meter to measure the amount of fuel unloaded."

Page 13–9–8. Sec. E, Art. 1—General, change to read as follows:

"Diesel fuel oil deliveries may be made by tank cars, highway truck transports, barges, private pipelines, common-carrier pipelines or combinations of these methods, depending upon the locality, economics, etc. Planning should include the possibility of using all available means of delivery and designing the facility so that the method of delivery can be varied in the direction of greatest economical advantage without interruption of service.

While tank cars used for diesel fuel delivery are so constructed that they can be unloaded through the valve at the bottom of car or through the dome opening at the top, only dome unloading is generally recommended. Unloading from the bottom of the car is not considered acceptable practice in most localities but may be necessary under emergency conditions.

Highway transport trucks can be unloaded from the top or bottom but are best suited to bottom unloading, since most of them are of the multi-compartment type,

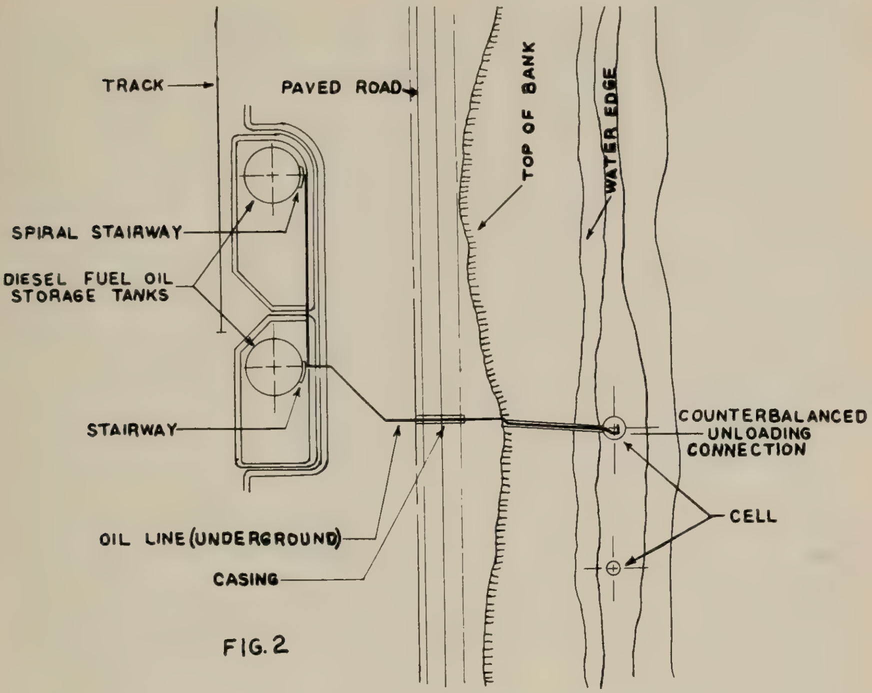
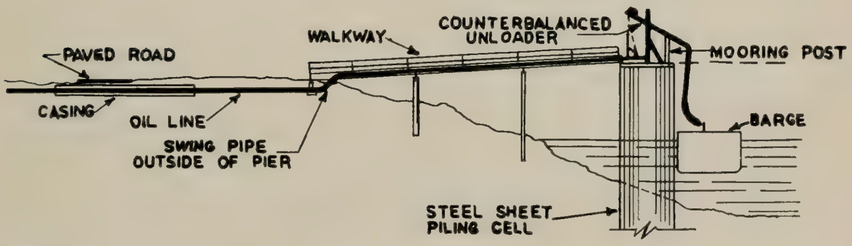
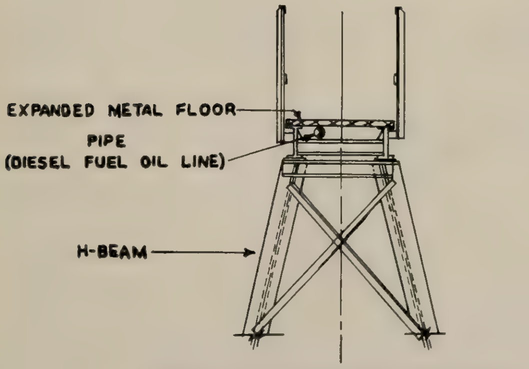


FIG. 2



ELEVATION



SECTION THROUGH WALKWAY

FIG. 3

connected to a common header at the bottom. Local regulations should be investigated in this respect. These highway vehicles can use the same unloading facilities as tank cars, usually with the accompaniment of minor piping changes to provide a permanent place for connection of the unloading hose and a service road capable of carrying the load. Pumps used to unload tank cars can also be used to unload highway transports. Trucks equipped with their own unloading pumps are available but an extra cost is usually involved. However, local conditions may permit a saving in labor which could offset this extra cost and this factor should be investigated.

Barge unloading is more specialized and is subject to the regulations of local harbor and/or waterway regulatory bodies. Generally, the oil is handled by pumps on the barges. One or more mooring cells, provided with an access bridge carrying the piping, may be used. Unloading masts of swivel design are desirable to provide for lateral variations in the location of the barges and also to handle water-level stages from pool to flood. Approved navigation lights are required. Also, some form of shelter is often requested for barge personnel during the period of unloading.

Private pipeline delivery of diesel fuel, where a railroad or an oil company runs a line from one property to the other simply to supply fuel to the railroad, may require only a connection to the storage tank inlet.

Facilities for delivery of diesel fuel from common-carrier pipelines require considerable planning. Assistance in this respect is readily available from the carrier. There are several general factors to be considered:

a. A manifold may be installed on the main carrier line to permit its use by other customers and then allow railroad fuel to be directed to railroad storage when desired.

b. The branch line from the manifold to railroad storage may be larger than the normal railroad fuel line because of the high pumping rate in the common carrier.

c. A tank of suitable capacity is needed to handle the separation liquid which is placed between different shipments in the pipeline. This is frequently referred to as the "Trans-Mix" tank. Standpipe-type steel tanks of 500 to 1000-bbl capacity are suitable for this service.

d. Railroad pipelines should be carefully insulated from the carrier line and from tanks so that cathodic protection is not diverted to these structures.

Page 13–9–10. Under Sec. G, Art. 4—Construction Measures to Minimize Accidental Ignition, under *Grounding,* add the following: See AAR Electrical Manual.

Report on Assignment 2

Prevention of Corrosion in Hot Water Heating Systems

J. J. Dwyer (chairman, subcommittee), R. C. Archambeault, W. E. Billingsley, P. J. Calza, C. E. DeGeer, H. E. Graham, G. F. Metzdorf.

Your committee presents the following final report with the recommendation that it be adopted and published in Chapter 13 of the Manual at the end of Part 4—Water Treatment.

CORROSION CONTROL IN HOT WATER HEATING SYSTEMS

The following recommended practice is concerned with the type of heating system in which hot water is supplied from a boiler to the point of radiation and then returned to the boiler through a closed system of piping either by gravity or circulating pumps.

1. Mechanical Concepts

If a hot water system is properly designed and closed, and is properly cleaned prior to operation, there may be little or no need for chemical treatment as long as the system is maintained in such condition. The appearance of corrosion in such a system will indicate, usually, the existence of a mechanical or maintenance defect that needs to be corrected.

Since, in such closed systems, the water is returned to the boiler either by gravity or by circulating and return pumps, very little makeup water is normally added; therefore, there is little opportunity for corrosion-producing contaminants to enter and cause damage. However, if appreciable amounts of makeup water are added to a system to replace losses from leaks, blowdown, summer drainings, and the like, then it is wise to consider chemical treatment.

If corrosion is found it will usually have originated from any of three sources, viz., (1) acid water from dissolved carbon dioxide, (2) other dissolved gases, usually oxygen, and (3) galvanic action between dissimilar metals in the system. Prevention of air infiltration at pumps, fittings, valves, vents and compression or expansion tanks, therefore, becomes vitally important, as well as avoiding repeated introduction of makeup water. Reference 1 points out the extreme importance of preventing such infiltration, and of good mechanical design. Adequate maintenance thus becomes a necessity.

2. Chemical Concepts

The cleaning of a new hot water heating system is often overlooked. It is common practice to clean new steam boilers to remove oil and grease introduced in manufacture. The same contaminants are usually present in a new hot water system, including such substances as pipe dope, cutting oils, soldering flux, dirt and sand, and will be distributed throughout the entire water circuit. Such foreign matter can contribute to corrosion potential by the formation of anodic-cathodic areas under deposits. Organic materials may decompose to form gases and acidic water. Systems with low pH water may develop pump-seal and gland problems, leaks at air vents, abnormal relief valve operation and leaks at pipe joints. Therefore, cleaning of hot water systems is quite important. If cleaning is not performed when needed, and leaks develop, then excessive makeup will be required, introducing oxygen, and corrosion problems may be expected to become severe.

A cleaner that has given good results is a mixture of sodium metasilicate and sulfonated alcohol-type wetting agent in proportions of 3.0 lb and 0.3 lb, respectively, to each 100 gal of water. The procedure is to fill the system, open the vent, and circulate the cleaner at the hottest operating temperature for about 4 hr. After draining off the cleaning solution, the system must be thoroughly flushed or rinsed with plain water until there is no indication of foaming. Other chemicals have been suggested for such cleaning; these are described in the references, particularly Reference 1.

Chemical treatment in hot water heating systems is recommended as good insurance against the corrosion damage that will occur when mechanical failures allow oxygen to enter the system. Inhibitors are now available which protect the metallic components of the system from attack by producing a barrier at the metal-water interface, thus rendering the metal passive to attack. These inhibitors maintain a pH of about 9.0 to 9.5 in the circulating water. Steam boiler water treatments, with their higher pH values, which are so detrimental to the non-ferrous metals, are not recommended.

The two types of inhibitors most commonly used are the chromate type and the nitrite-borate type. Both are readily available from most of the recognized water-treating companies serving railroads. The chromate inhibitor will probably be the more economical, due to the lower dosage requirements. Some of the chromate-polyphosphate-combination inhibitors give adequate protection at 150–250 ppm Na_2CrO_4, or even at 25–35 ppm Na_2CrO_4. The disadvantages of chromate are that it is toxic (0.05 ppm of chromium will contaminate drinking water); it presents waste-disposal problems; and it is considered a dermatitis-producing material. In strong concentrations it may have a detrimental effect on pump seals. It is a strong oxidizing agent, is a good conductor of electricity when in solution and enhances stray current electrolysis. It should be especially noted that chromate treatments should not be used in a boiler whose feed system is connected to a city water supply.

The nitrite-borate inhibitor presents minimum dermatitis hazards, and does not appear to have any detrimental effect on pump seals. Dosages of 3000–3500 ppm may be required for corrosion control.

The more recent HTW (high temperature water) systems, which operate at elevated pressures to utilize smaller radiation areas comparable to steam heat systems, also can be protected by the treatments recommended above.

3. Summary

Measures to consider in protecting a hot water heating system from corrosion:

1. Good mechanical design.
2. Good cleaning of a new system or after repairs.
3. Good maintenance.
4. Good chemical treatment.
5. Do not drain system unless absolutely necessary.
6. Do not permit entry of gases into system.

REFERENCES

1. "Good Procedures Forestall Corrosion in Hot Water Heating Systems," R. H. Hayman, *Heating, Piping and Air Conditioning,* p. 115, March 1961.
2. "Corrosion Prevention in Steam and Condensate Lines," AREA Manual, page 13–4–17.
3. "Corrosion Prevention in Potable Hot Water Systems", AREA Manual, page 13–4–23.
4. Nordell, E., "Water Treatment for Industrial and Other Uses," Reinhold Publishing Corporation, New York, 1961.
5. Powell, S. T., "Water Conditioning for Industry," McGraw–Hill Book Co., Inc., New York, 1964.
6. Uhlig, H. H., "Corrosion and Corrosion Control," John Wiley & Sons, Inc., New York, 1964.

Report on Assignment 3

Design, Construction and Operation of Railroad Sanitary and Servicing Facilities, and Relations with Governmental Agencies Pertaining to these Facilities

C. F. Muelder (chairman subcommittee), J. M. Bates, T. W. Brown, P. J. Calza, J. H. Langston, J. C. Roberts, J. P. Rodger, E. M. Walters, J. E. Wiggins.

Under this assignment your committee reports to the Association on coach servicing facilities, and on laws, ordinances, regulations and decisions of various governmental agencies concerned with public health and sanitation.

The U. S. Department of Health, Education and Welfare has issued the 1964 Revision of Publication No. 95, entitled, "Handbook on Sanitation of Railroad Passenger Cars." This revised standard is in six parts: Part I—General Standards, which deals with water supply facilities, toilet and lavatory facilities, and ventilating and heating; Part II—Coach Construction; Part III—Sleeping Car Construction; Part IV—Dormitory Car Construction; Part V—Lounge, Club and Parlor Car Construction; and Part VI—Construction and Operation of Dining Cars. Copies of this publication are available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 20402.

The U. S. Public Health Service is now conducting a comprehensive study of water quality and pollution control in the Great Lakes and the Illinois River Basin. Completion of the study is expected in 1967. The basic investigations of existing water quality have been completed. Activities are now under way to determine the measures of control necessary to achieve the goals desired. As a result of this study, the U. S. Public Health Service will make recommendations to Congress with respect to water quality and pollution control, along with a plan of enforcement. The committee recommends that new railroad installations that might be affected by new legislation resulting from this study be engineered and planned accordingly.

A model law has been drafted by the U. S. Public Health Service to control water supply and sewerage systems. It is entitled, "Urban Water Supply and Sewage Systems Control Act." Copies were distributed to officials of all the states by the Surgeon General, who urged them to give it serious consideration.

The committee calls attention to the following provisions of this model law:

(a) It is proposed that legislation be enacted endowing the appropriate state and local agencies with regulatory authority over individual wells and septic-tank installations, with a view to minimizing and limiting their use.

(b) The proposed legislation would give the state department of health the authority to establish regulations to limit, control or prohibit the use of individual wells and septic tanks.

(c) Where comprehensive community systems are either already available or can be feasibly made available, connection to such systems would be required.

(d) Where comprehensive community systems are not immediately available, but are officially programmed to become available within a reasonable period of time, small community water and sewerage systems would be required, wherever feasible, since these can be incorporated later into large systems.

(e) The suggested legislation would require all urban municipalities to prepare, adopt and submit to the state department of health for its approval official plans for water and sewerage facilities.

Since the railroads have many private wells and sewage-disposal units that might be affected, this proposed legislation should be followed closely.

This report is presented as information.

Report on Assignment 4

Cathodic Protection of Pipelines and Steel Storage Tanks

Collaborating with Committee 18

W. F. Arksey (chairman, subcommittee), A. E. Dulik, T. I. Gray, T. L. Hendrix, H. M. Hoffmeister, F. O. Klemstine, C. F. Muelder, E. T. Myers.

Your committee has reviewed the reports on this subject published in 1957, 1959, 1961 and 1963, and recommends that the following consolidation of these reports be adopted and published in the Manual.

CATHODIC PROTECTION OF PIPELINES AND STEEL STORAGE TANKS

A. INTRODUCTION TO CATHODIC PROTECTION

1. Cost of Underground Corrosion

Corrosion of buried plant and contingent losses are costing American industry about $1 billion per year. Much of this loss can be avoided by proper preventive measures. Thus it is good business for managements to give sympathetic support to their engineers concerned with the application of cathodic protection.

2. Principle of Prevention

Corrosion of metals reverses the reactions undergone when the metals were originally refined, that is, it returns metals to their natural state as ores and compounds. This attack is always evidenced by a flow of electric current. In most cases a chemical change initiates the current flow, but, conversely, a flow of impressed current from metal to soil can cause chemical change. Regardless of whether the chemical change initiates the current flow or vice versa, the corrosion damage is physically similar, and if such current out-flow can be prevented, corrosion cannot occur.

3. Coating as a Protective Measure

If a structure could be coated with an impervious and durable layer of electric insulating material, all flow of current to or from the soil would be prevented. Coatings are available that provide reasonable protection if carefully applied, but most will deteriorate or become damaged in time, tending to focus corrosion to the damaged areas.

4. The Cathodic Protection Technique

The technique of cathodic protection consists of impressing inward-flowing protective currents in a structure to counteract the structure's outward-flowing currents that cause corrosion. Two sources of protective currents are available. Where considerable current is required, direct-current generators or rectifiers are connected by insulated wires positively to the anodes and negatively to the structure. Where less protective current is required, sacrificial anodes of magnesium, aluminum or zinc are buried and connected to the structure by insulated wires. These anodes will generate current (as in a battery) which will flow through the soil into the structure. These sacrificial anodes will be corroded by the current they discharge to the soil and must be renewed at intervals. However, correct sizing can give years of economical protection.

5. Cathodic Interaction Problems

The current applied to one structure may enter adjacent structures, causing corrosion where it leaves that structure; therefore, any operator planning a cathodic protection system should notify operators of neighboring buried structures so that all can cooperate. The effect of cathodic protection systems on signal systems should be investigated to avoid false signal operation.

In numerous areas where transit companies have abandoned electrified track, operators of adjacent structures are finding that removal of the stray track currents has allowed the weaker currents of natural corrosion to flow unopposed. The track current no longer was giving cathodic protection to the adjacent structures. A similar condition could develop on those railroads which are abandoning electrified lines.

B. CATHODIC PROTECTION TECHNICAL PRACTICES

1. Current Required for Proper Cathodic Protection

Most engineers concur that the most practical method of determining protective current requirements is to apply such current to the structure on a trial basis, using portable power supplies and temporarily installed anodes. The current flow can be adjusted until field measurements indicate that cathodic protection has been established to prevent further corrosion.

The adequacy of protection is determined by measuring the potential it establishes between the structure and the soil under various rates of current flow. For making the voltmeter contact to the soil, a suitable non-polarizing reference electrode (or half-cell) is used. For testing on steel or black-iron structures, generally a copper sulfate half-cell is used. Based on such potential measurements, certain widely accepted practical criteria, indices, or "yardsticks" of adequate cathodic protection have been developed. Using the half-cell reference electrodes, experience has shown that adequate protection of steel or iron structures usually is obtained if their potential is reduced by the protective current to about —0.85 v with respect to the copper sulfate half-cell in contact with the soil. For galvanized pipe, a potential with respect to the copper sulfate half-cell of about —1.10 v is required for protection.

2. Location of Current Supply Points

The location at which the protective current should be applied to a structure and the amount of current required may be determined by use of batteries or portable generators connected between the structure and temporary anodes. Readings should be taken along the structure at points progressively further from the power supply connection. Depending on conditions, it may take minutes, or several days, for the structure-to-soil potentials to become stable. Consequently, the equipment should be left in place until reasonably stable conditions are established.

The choice of current supply locations depends on the type of permanent power supply selected. The scope of this report, however, is intended to cover small installations where galvanic anodes are used. On large extensive systems, the services of a competent corrosion engineer is recommended.

3. Available Current Sources

Where a large amount of current per location is required, it is generally more economical to use external power sources, although in some cases the use of a large group of galvanic anodes may be preferable.

Galvanic anodes can efficiently produce only a few hundred milliamperes per anode, but on coated structures or on plants of limited extent, they provide adequate protection. It is often practical to install galvanic anodes, singly or in groups, at frequent intervals along a long pipeline, thus obtaining the protection that would be afforded by rectifier-type supplies at wider spacings. For galvanic anodes, magnesium is now favored by corrosion engineers. Magnesium ribbon is available which can be laid parallel to the pipeline to provide a continuously distributed anode.

Open-circuit potentials between properly installed galvanic anodes and reference half-cells contacting adjacent soil are relatively constant—that of magnesium relative to a copper sulfate half-cell being about 1.50 v, and that of zinc to the same reference cell being about 1.0 v. However, it is often impossible accurately to predict the effective potential of a galvanic anode relative to an undisturbed buried structure for two reasons: (1) The theoretical relative potentials calculated from the values listed in "electromotive series" tables of handbooks are seldom realized when the two metals are placed in soil or water; (2) the innumerable and often wide variations of undisturbed structure surface and burial environment cause corresponding and unpredictable effects on these potentials. Thus, only local experience or testing can determine with reasonable accuracy what effective open-circuit anode-to-structure potential may be realized in a particular installation.

C. INSTRUMENTATION

In making a field survey it is necessary to measure electrical potentials and currents associated with corrosion of the structure in question. When cathodic protection has been applied to a structure, electrical measurements are made to determine when corrosion has been halted. The corrosion potentials and current normally measured are small, extending down to millivolts and milliamperes, but cathodic protection and electrolysis currents range from milliamperes to hundreds of amperes. Therefore, instruments must cover a wide range of current and potential measurements. Improperly taken measurements in the field may result in a poorly designed system.

1. Potential Measuring Instruments

Four types of millivolt meters are used: (1) Low-resistance instruments, (2) High-resistance instruments, (3) Potentiometer voltmeters, and (4) Vacuum-tube voltmeters. There are two general rules which should be followed in choosing the instruments to be used:

1. The instrument should be sensitive enough to prevent the passage of sufficient current to change the potential being measured or polarize the reference electrode being used, thereby changing its half-cell potential.
2. The internal resistance, if moving coil and series resistors are used, should be very high compared to the external resistance of leads and resistance to earth of the reference electrodes. If readings with 1 percent accuracy are required, the instrument's resistance must be 99 times as high as the resistance of the leads, contacts and electrodes (unless corrections are made for external resistances).

A high-resistance voltmeter (50,000 to 500,000 ohms-per-volt sensitivity) is used to measure structure-to-earth potentials, using a reference electrode. A potentiometer is very useful for making similar measurements when leads are long, such as in pipeline measurements, as it is possible to cancel out the resistance of the leads by proper use of the potentiometer circuit.

Multi-combination meters have been developed specifically for field and laboratory testing that combines all of the instruments required for electrolysis and corrosion investigations and cathodic-protection testing into one compact instrument, usually consisting of two highly sensitive microammeters, with various switches to cover a complete range of potential from 2 mv to 100 v, and current ranges from 1 milliamp to 20 amps. They also provide a low-resistance millivoltmeter, a high-resistance millivoltmeter and a potentiometer using a calibrated galvanometer with calibrated ranges. These meters are furnished with complete wiring diagrams and operating instructions.

After securing equipment to make cathodic-protection tests, experiments should be run with an earth-filled box moistened slightly with water to increase its conductivity. By use of such a box, proficiency in the operation of the meter can be developed, and first-hand knowledge of galvanic currents between various metals can be obtained.

In addition to the instruments for measuring potential, current and resistance, it is necessary to have a copper sulfate or other type of electrode as a reference electrode. The copper sulfate electrode (which is usually used) consists of a plastic tube in which a copper rod is immersed in a copper sulfate solution. The bottom of the tube is closed by a porous plug through which contact is made with the ground.

D. DESIGN OF CATHODIC PROTECTION SYSTEM FOR PIPELINES

1. Soil Potentials

A survey of the pipe-to-soil potentials are made by using a high-resistance voltmeter or potentiometer and a copper sulfate electrode. The negative pole of the voltmeter is connected to an exposed point on the pipeline and the positive pole to the copper sulfate half-cell. The cell should be placed in good contact with moist earth. Readings with the cell are taken every 50 ft, extra readings being taken to pin-point the location of the lowest potential. A No. 22 lead wire with a plastic coating may be used to reach several hundred feet before moving the instrument. Current flow in the pipe is determined by measuring the potential drop along a calibrated length of pipe as shown in Fig. 2, Note 2.

The above tests are made to assure that no unusual condition exists, such as stray current from direct-current sources or particularly low pipe-to-soil potentials.

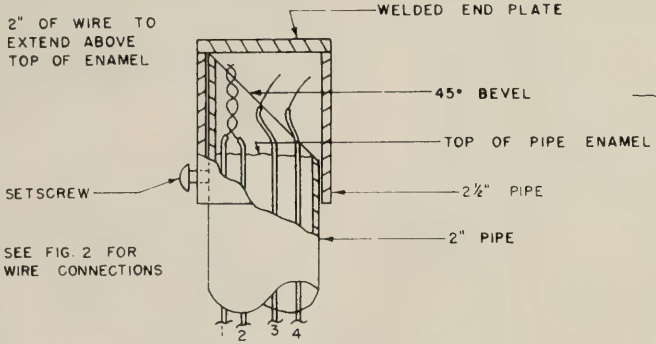

2" OF WIRE TO EXTEND ABOVE TOP OF ENAMEL
WELDED END PLATE
45° BEVEL
TOP OF PIPE ENAMEL
SETSCREW
2½" PIPE
2" PIPE
SEE FIG. 2 FOR WIRE CONNECTIONS
1
2
3
4

FIG. 2A TEST BOX DETAIL

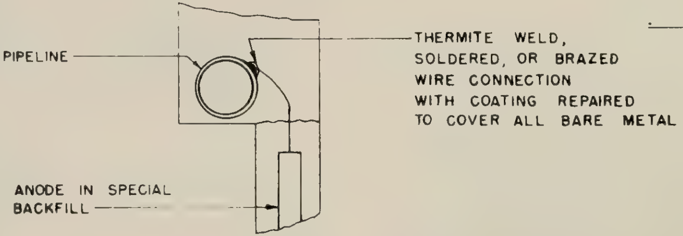
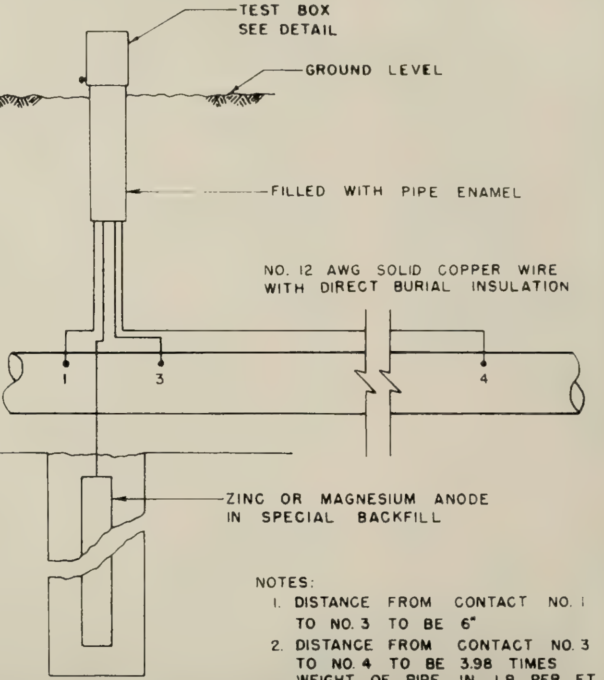

PIPELINE
THERMITE WELD, SOLDERED, OR BRAZED WIRE CONNECTION WITH COATING REPAIRED TO COVER ALL BARE METAL
ANODE IN SPECIAL BACKFILL

FIG. 1 TYPICAL ANODE


TEST BOX SEE DETAIL
GROUND LEVEL
FILLED WITH PIPE ENAMEL
NO. 12 AWG SOLID COPPER WIRE WITH DIRECT BURIAL INSULATION
1
3
4
ZINC OR MAGNESIUM ANODE IN SPECIAL BACKFILL

NOTES:
1. DISTANCE FROM CONTACT NO. 1 TO NO. 3 TO BE 6"
2. DISTANCE FROM CONTACT NO. 3 TO NO. 4 TO BE 3.98 TIMES WEIGHT OF PIPE IN LB PER FT

FIG. 2 COMBINED ANODE & TEST BOX

TYPICAL INSTALLATION FOR CATHODIC PROTECTION

2. Soil Resistivity

Soil resistivity tests are made by either the four-pin method, which gives an average reading to a specified depth, dependent on the distance between pins, or by the "Collins Bar" method, which measures resistivity of only the small area of earth at the point of probe. (Use of the four-pin method will be described in more detail later.)

Resistivity tests show two things: (1) A low resistivity permits easy flow of corrosion currents and may indicate a corrosion-prone environment; (2) low resistivity will permit easy flow of cathodic protection current which might be applied, giving greater current from a galvanic anode or lower power requirements from a rectifier unit. A high resistivity probably means less worries from corrosion. Resistivities will generally vary from 500 ohm-cm upward; soils with resistivities below 2500 ohm-cm are classed as severely corrosive.

3. Anode Installation

It is preferable to place the anodes in a vertical hole in the bottom of the trench, to prevent the backfill material from settling away from the anode, as might happen of the anode is laid in a horizontal position; also, the anode will be in moist soil when located below the bottom of the trench. The anode lead wire is connected to the pipeline by a thermite weld, taking care thoroughly to coat the weld metal to prevent setting up a corrosion cell between the weld metal and the pipe. Fig. 1 shows a typical anode installation. Figs. 2 and 2A show wiring connections with a test box. No dimensions are shown for the size of the hole which should be bored for installing anodes, as the diameter varies with the size of the anode. A hole 3 to 4 in larger in diameter than the anode will allow room for special backfills, if required.

E. PRACTICAL APPLICATION

AREA Bulletin 574, Vol. 64, November 1962, gives details of cathodic protection on two underground diesel fuel oil tanks to serve as an example of cathodic protection design. The four-pin method of obtaining soils resistance measurements is described below in a practical example:

Pin Spacing 5 Ft 6 In

$E = 1.86$ volts $\quad I = 2.30$ milliamperes

Resistance $R = 2aE/I$

Where $R =$ resistivity in ohm-centimeters

$a =$ spacing in centimeters (spacing in feet $\times$ 12 $\times$ 2.54)

$E =$ measured potential between two inner terminals

$I =$ current between two outer terminals

Calculation $$R = \frac{(2 \times 5.5 \times 12 \times 2.54) \times 1.86}{0.0023}$$

$R = 273{,}000$ ohm-centimeters

Method of Calculating Life of Anodes

Magnesium anodes are estimated to produce 600 amp-hr per lb of metal consumed.

hours per year = 8760
amp-hr/lb magnesium = 600

Therefore, $\frac{8760}{600} = 14.6$ lb of magnesium required to generate 1 amp of current for a period of one year. If we have a 50-lb magnesium anode generating 0.084 amp, then the life of anode $= \frac{50 \times 1 \times 0.084}{14.6} = 40.8$ years

Experiments with various types of backfill material around buried anodes have been conducted to determine the effectiveness of various kinds and methods of installation. The most successful backfill proved to be a wet mixture of two parts bentonite dry powder, one part anhydrous sodium sulfate and one part gypsum. These materials were mixed into a thick slurry and poured around the anodes suspended in the hole. This type of installation requires a little more time than a prepacked anode installation, but for applications where maximum current is desired from an anode, the wet mix will give better results.

It is recommended that soil potential readings be taken with a copper sulfate electrode along the center line of the tank after the anodes have been installed, comparing these readings with readings taken prior to installation of the anodes. Endeavor to obtain an increase of 0.3 v on well coated structures and a 0.10-v increase on a poorly coated structure. Other authorities recommend that a minimum potential of 0.85 v be obtained between the tank and the soil, using a copper sulfate electrode. Readings of 0.85 v were obtained at some distance from the tank in question.

The following procedure is recommended for designing a cathodic protection system for underground tanks:

(1) Determine soil resistance by the four-pin, soils-box, or other suitable method.
(2) Read tank-to-soil potentials every 5 ft over center of tank.
(3) Select an anode that will have 15 years of life. (Tables are available from manufacturers of anodes showing current output and life expectancy of various types and sizes of anodes in soils of varying resistances.)
(4) Install six or eight anodes per tank, depending on the length of the tank.
(5) After anodes have been in service for three weeks to a month, take readings similar to those shown in AREA Bulletin 574, Vol. 64, 1963, page 148, as it may be found that more anodes are required. Experience gained with each installation will prove beneficial in later designs.

REFERENCES

1. Corrosion and Its Control—Marshall E. Parker, published by the Oil and Gas Journal.
2. Galvanic Couples and Cathodic Protection—M. C. Miller.
3. Corrosion of Buried Metals and Cathodic Protection—M. C. Miller.
4. Characteristics and Field Use of Electrical Equipment for Corrosion Investigations and Cathodic Protection—M. C. Miller.
5. Cathodic Protection for Earth Buried Pipe Lines and other Metal Structures—Bureau of Mines, Circular 7827—April 1958.
6. Zinc as a Galvanic Anode Under Ground—American Zinc Institute, 60 E. 42nd St., New York, N. Y.
7. Zinc as a Galvanic Anode Under Water—American Zinc Institute, 60 E. 42nd St., New York, N. Y.
8. How Zinc Controls Corrosion—American Zinc Institute, 60 E. 42nd St., New York, N. Y.

9. Proceedings of the Second Annual Appalachian Underground Corrosion Short Course, 1957.
10. Technical Bulletin No. 48—Engineering Experiment Station—West Virginia University—Morgantown, W. Va.
11. Magnesium Anodes for Cathodic Protection—Dow Chemical Company.
12. High Current Magnesium Anodes for Corrosion Control—Standard Magnesium Corporation.
13. AREA Proceedings, Vol. 59, 1958, pp. 421–423.
14. AREA Proceedings, Vol. 60, 1959, pp. 271–274.
15. AREA Proceedings, Vol. 62, 1961, pp. 242–244.
16. AREA Proceedings, Vol. 64, 1963, pp. 148–151.
17. Corrosion of Underground Metal Structures, and Materials and Devices for Combatting It, by H. C. Boone—AREA Proceedings, Vol. 65, 1964, pp. 704–713.

Report on Assignment 7

Installation and Maintenance of Liquefied Petroleum Gas Facilities

E. R. Schlaf (chairman, subcommittee), H. E. Graham, W. E. Billingsley, T. W. Brown, C. E. DeGeer, J. H. Langston, J. C. Roberts.

Your committee has reviewed the report on this subject published in Bulletin 581, Proceedings, Vol. 65, 1964, pages 223 to 243, incl., and recommends that the following condensation be adopted and published in the Manual.

INSTALLATION AND MAINTENANCE OF LIQUEFIED PETROLEUM GAS FACILITIES

A. PROPERTIES AND POTENTIAL HAZARDS OF LIQUEFIED PETROLEUM GAS

Liquefied petroleum gases, commonly referred to as LP-Gas, are liquids when under pressure but vaporize when the pressure is released. They are stored as liquids and used as gases. When in the vaporized state, the gases present a hazard comparable to any flammable natural or manufactured gas. Since they are heavier than air, ventilation where they are used requires special attention even though natural diffusion takes place. In the liquid condition, the gases present a hazard similar to that of a highly flammable liquid but with more rapid evaporation. The gases are practically odorless as produced, so, unless they are to be used in the manufacture of certain chemicals, it is necessary to add an odorizing agent to facilitate detection of escaped gas by smell.

Liquefied petroleum gases may contain propylene, butylene and isobutane, but LP-Gas generally consists mainly of propane and butane. Fig. 1 lists the average properties of commercial propane and butane. It will be noted that under winter conditions butane would not evaporate readily without the use of a vaporizer.

When LP-Gas escapes, it may collect in low areas. As stated in Fig. 1, 1 lb of propane will produce approximately 8 cu ft of gas at atmospheric pressure, or about 36 cu ft of gas per gallon. Since the lower flammable limit of propane is 2.2 percent, it can be seen that only 1 gal of propane, under theoretically ideal conditions, could render explosive approximately 1400 cu ft of air. Since LP-Gas is heavier than air,

REGO LP-GAS
SERVICEMAN'S MANUAL

USEFUL INFORMATION ABOUT LP-GAS*

	PROPANE	BUTANE
Formula	C_3H	C_4H_{10}
Boiling Point, F	—44	32
Specific Gravity of Gas (Air = 1.00)	1.53	2.00
Specific Gravity of Liquid (Water = 1.00)	0.51	0.58
Lbs. per Gallon of Liquid at 60 F	4.24	4.81
BTU per Gallon of Gas at 60 F	91690	102032
BTU per Lb. of Gas	21591	21221
BTU per Cu. Ft. of Gas at 60 F	2516	3280
Cu. Ft. of Vapor at 60 F/Gal. of Liquid at 60 F	36.39	31.26
Cu. Ft. of Vapor at 60 F/Lb. of Liquid at 60 F	8.547	6.506
Latent Heat of Vaporization at Boiling Point BTU/Gal.	785.0	808.0
Combustion Data:		
Cu. Ft. Air Required to Burn 1 Cu. Ft. Gas	23.86	31.02
Flash Point, F	156	N.A.
Ignition Temperature in Air, F	920-1020	900-1000
Maximum Flame Temperature in Air, F	3595	3615
Limits of Inflammability, Percentage of Gas in Air Mixture:		
At Lower Limit—%	2.4	1.9
At Upper Limit—%	9.6	8.6
Octane Number (ISO-Octane = 100)	Over 100	92

* Commercial quality Figures shown in this chart represent average values

REGO LP-GAS
SERVICEMAN'S MANUAL

VAPOR PRESSURES OF LP-GASES

TEMPERATURE (F)	APPROXIMATE PRESSURE (PSIG)	
	PROPANE	BUTANE
—40	3.6	
—30	8.0	
—20	13.5	
—10	20.0	
0	28.0	
10	37.0	
20	47.0	
30	58.0	
40	72.0	3.
50	86.0	6.9
60	102.0	11.5
70	120.0	16.5
80	140.0	22.0
90	165.0	29.0
100	190.0	37.0
110	220.0	46.0

Courtesy of Bastian Blessing Co., Chicago, Ill.

Fig. 1

bottom ventilation of buildings in which LP-Gas is handled is essential. Explosion-proof (Class I, Group D) motors, motor controls and lighting are required in vaporizer houses (except those housing direct-fired vaporizers), pump houses and cylinder filling rooms or other similar locations. Vapor-proof flashlights should be used.

There is a hazard from the refrigerating effect if the liquid is accidentally sprayed on the skin or in the eyes.

The average vapor pressure of commercial propane gas is 200 psig at 100 deg F. Tests conducted by the National Bureau of Standards have shown that the normal maximum liquid temperature in aboveground storage tanks of over 1200 gal capacity will not exceed 100 deg F. Therefore, the maximum vapor pressure to be expected is 200 psig. To this must be added the pumping pressure when transferring the liquid.

B. LOCATION AND DESIGN OF STORAGE FACILITIES

After determining the fuel requirements, the first step in planning an LP-Gas installation is to obtain a copy of the latest edition of NFPA Standard No. 58, covering the storage and handling of this material. It may be obtained from the National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass., at a cost of 75 cents per copy. The second step is to obtain Bureau of Explosives Circulars 17, 17B, 17C and 17E. They may be obtained from the Bureau of Explosives, AAR, 63 Vesey Street, New York 7. These circulars cover track clearances, blue-flag protection, derail protection, warning signs, laying of pipelines under ground on railroad property, laying of pipelines under tracks, proper illumination at car unloading points, bonding and grounding of tracks serving LP-Gas installations and recommended clearances from wire lines when metal gaging rods are used.

After these two pamphlets are read and understood, the third step in planning an LP-Gas installation is to survey the area for the most ideal location. It should constantly be borne in mind that any liberated gas can flow to low points. The contour of the ground should be studied, and the possibility of derailments, particularly those involving passenger trains, while tank cars are being unloaded should be considered. Where the service spur can be placed on the same side of the main line as the storage tanks, this eliminates the necessity of laying LP-Gas pipelines under the tracks. The spur should be so located that trucks requiring service will not have to cross the main line to reach the main-traveled through highway. A sparsely populated area is preferable. Some railroads confine the spur track to petroleum service only, or, if it is used by other industries, the end of the spur, adequately protected by derail, may be used for LP-Gas unloading. Circular 17 requires a near-rail to near-rail clearance of at least 25 ft, and as much more as is practically possible, from the nearest track over which passenger trains operate. Some railroads require 100 to 200 ft centers, depending on tank capacity, from tracks over which any trains are operated. The NFPA standard clearances from buildings and property lines are shown in Fig. 2.

The fourth step is obtaining the approval of local municipal authorities who are sometimes governed by the recommendations of the state fire marshal, or other duly designated state official, but who in many cases are more strict than at the state level. Even if there is no real authority, most states require approval of plans by the state fire marshal prior to the beginning of construction.

After the necessary approval of the plans is secured, construction may begin. Strict adherence to the plans is essential. A typical industrial installation is shown in Fig. 3. When the installation has been completed and tested, the system must be purged into service by the contractor or the LP-Gas supplier. Purging is discussed later in this report.

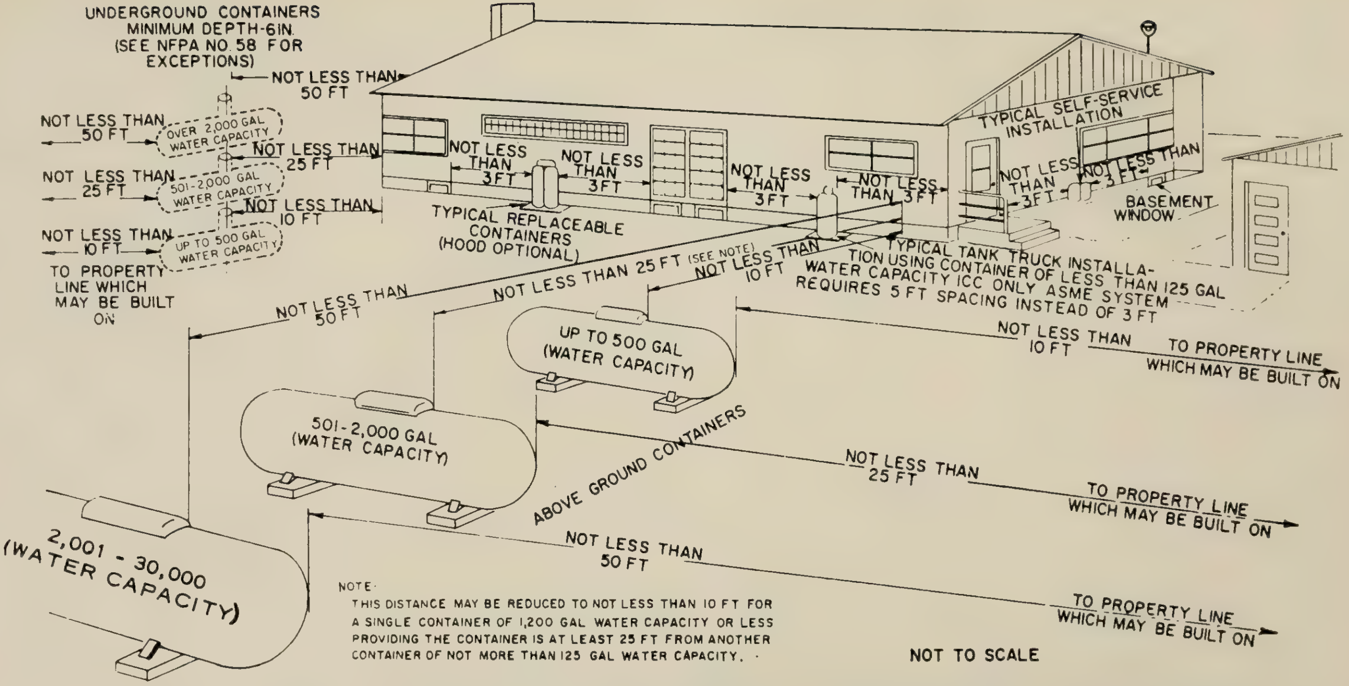

UNDERGROUND CONTAINERS
MINIMUM DEPTH-6IN.
(SEE NFPA NO. 58 FOR EXCEPTIONS)
NOT LESS THAN 50 FT
NOT LESS THAN 50 FT
OVER 2,000 GAL WATER CAPACITY
NOT LESS THAN 25 FT
NOT LESS THAN 25 FT
501-2,000 GAL WATER CAPACITY
NOT LESS THAN 10 FT
NOT LESS THAN 10 FT
UP TO 500 GAL WATER CAPACITY
TO PROPERTY LINE WHICH MAY BE BUILT ON
NOT LESS THAN 3FT
NOT LESS THAN 3FT
NOT LESS THAN 3FT
NOT LESS THAN 3FT
TYPICAL SELF-SERVICE INSTALLATION
NOT LESS THAN 3FT
NOT LESS THAN 3 FT
BASEMENT WINDOW
TYPICAL REPLACEABLE CONTAINERS (HOOD OPTIONAL)
TYPICAL TANK TRUCK INSTALLATION USING CONTAINER OF LESS THAN 125 GAL WATER CAPACITY ICC ONLY ASME SYSTEM REQUIRES 5 FT SPACING INSTEAD OF 3 FT
NOT LESS THAN 50 FT
NOT LESS THAN 25 FT (SEE NOTE)
NOT LESS THAN 10 FT
NOT LESS THAN 10 FT
TO PROPERTY LINE WHICH MAY BE BUILT ON
UP TO 500 GAL (WATER CAPACITY)
501-2,000 GAL (WATER CAPACITY)
ABOVE GROUND CONTAINERS
NOT LESS THAN 25 FT
TO PROPERTY LINE WHICH MAY BE BUILT ON
2,001 - 30,000 (WATER CAPACITY)
NOT LESS THAN 50 FT
TO PROPERTY LINE WHICH MAY BE BUILT ON
NOTE·
THIS DISTANCE MAY BE REDUCED TO NOT LESS THAN 10 FT FOR A SINGLE CONTAINER OF 1,200 GAL WATER CAPACITY OR LESS PROVIDING THE CONTAINER IS AT LEAST 25 FT FROM ANOTHER CONTAINER OF NOT MORE THAN 125 GAL WATER CAPACITY.
NOT TO SCALE

Fig. 2 - LP-GAS INSTALLATIONS SHOWING CLEARANCES IN COMPLIANCE WITH NFPA STANDARDS

Standards and regulations require that tanks and cylinders be placed no closer than stated minimum distances from buildings, property lines, etc. This drawing indicates which distances are involved, but a check should be made of applicable standards and regulations to determine actual distances required. Distances shown in cylinder installations mean from discharge of cylinder relief valve and/or regulator relief valve, whichever is nearest to lower opening in building. Spacing requirements for partially buried containers are the same as for buried containers. Distances shown in bulk tank installations are from nearest part of tank to object shown.

Courtesy of National Fire Protection Assn.

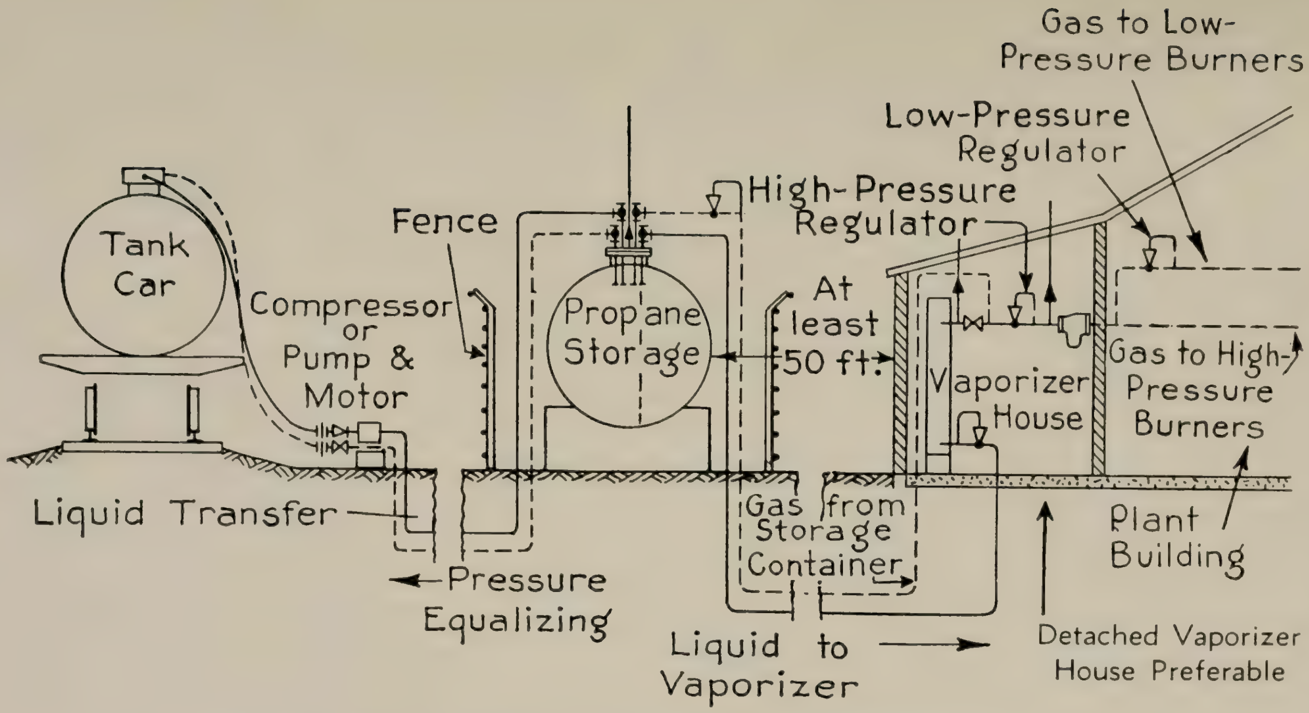


Fig. 3 - TYPICAL INDUSTRIAL INSTALLATION OF LIQUEFIED PETROLEUM GAS

Vaporizer house equipment is ordinarily used only with butane or butane mixtures or with propane in the case of heavy withdrawals from the container. If the vaporizer house is a separate building, the distance from the container may be reduced (minimum 10 ft for containers over 500 gal).

Courtesy of National Fire Protection Assn.

C. CARE AND MAINTENANCE OF EQUIPMENT

1. Compressors

The heart of the valve-type LP-Gas compressor is the suction and discharge valves. The best check of the valves is the performance of the compressor. If the pressure will not build up, the valves probably need attention. If new piston rings must be installed, they should be allowed to run in for several hours before the proper sealing effect can be expected. The oil level should be checked before unloading a car, and at least once more during the operation. The manufacturers' recommendations as to frequency of oil change and type of oil to be used should be followed closely. Frequent tightening of all assembly nuts is desirable, particularly those which pull two surfaces together upon a gasket. If gaskets require renewal, factory parts should be used if at all possible.

The function of the seal assembly is to exclude the atmosphere from the location where the crankshaft extends through the housing for power transmission. The efficiency of the compressor may be dangerously impaired because of improper lubrication, or if foreign matter works in between the two surfaces of the seal. In cases where the seal cannot be relapped locally, it would be well to replace it, returning the old seal to the factory for relapping.

Most LP-Gas compressors are mounted directly on top of the surge tank and connected to its intake side. This serves to maintain an even suction, thus eliminating the slamming of the excess flow valves that results from sudden impulses. This method of mounting also prevents any LP-Gas in liquefied form from passing into the compressor and doing serious damage to it. The surge tank should always be drained before starting the unit, piping the drainage out and away from the pump house. The drain line should be laid in such a way that water cannot condense in it and later freeze and block the pipe.

Proper belt tension is important. Matched V-belts are recommended. If a V-belt squeals, it is too loose or out of alinement. "Fiddle-string-tight" belts put an unnecessary strain on the motor and compressor bearings. Never attempt to adjust belt tension while the motor is running. Never put dressing on a V-belt, because if it contains a resin static electricity may be generated, and may discharge in the form of a spark.

2. Liquid Pumps

As with compressors, the heart of the liquid piston pump is the valve system. Piston rings may break, although this difficulty is rarely encountered. The manufacturer's recommendation regarding piston packing and lubrication should be followed.

One cause of the failure of any of the positive-displacement type of pumps to deliver liquid is "vapor lock." This may result from excessive pump speed. Starting and stopping the pump at 15-sec intervals may eliminate the condition. Other causes of vapor lock are inadequate size of the suction piping, a temporary obstruction in the piping, or both. Never attempt to bleed entrapped gases by loosening fittings. The fitting may break or "let go" and a serious injury might result.

A rotary pump requires close tolerances and accurate alinement to function efficiently. Only skilled mechanics may be expected to repair gear pumps properly. Always use the manufacturer's gaskets and replacement parts. It is sometimes advantageous to exchange pumping units, returning the pump to the factory for overhaul. Rotary pumps should never be run dry.

Internal rust, caused by the presence of moisture in LP-Gas, can damage iron pumps. It is, therefore, a good plan to operate such pumps a few minutes each day to dislodge rust accumulation. Approved strainers on the suction side of the pump are recommended.

3. Gaging Devices

There are six main types of liquid-level gages, but the three most generally used are fixed liquid level, rotary liquid level and slip tube. The rotary liquid-level gage consists of a curved metal tube, located on the tank interior, which may be rotated by means of a pointer-handle on the outside of the tank. A bleeder valve is opened and the handle moved to detect the liquid surface within the tank. The slip-tube gage is used extensively on storage tanks and universally on tank cars.

4. Periodic Testing of Storage Tanks and Relief Valves

The NFPA does not require periodic hydrostatic testing of storage tanks. Factory Mutual recommends an external inspection annually, and an internal inspection by a pressure vessel inspector every 10 years. One railroad requires a five-year visual inspection of the exterior surfaces of underground LP-Gas storage tanks if owned by an industy located on railroad property. The inspection may be waived if a test plate buried adjacent to the tank shows no appreciable corrosion on inspection.

The NFPA does not require the hydrostatic testing of relief valves on storage tanks but suggests a 5-year relief-valve test for tanks of 2000 gal capacity and over. When the valve is of the type requiring removal, the tank must first be emptied. When the type of valve permits, testing may be accomplished by an external lifting device equipped with an indicator to show the pressure equivalent at which it opens. Factory Mutual recommends that a five-year test of relief valves should be made by the system installer or the LP-Gas supplier. Some relief-valve systems are equipped with multiport valves installed under two or more safety-relief valves. By shifting the position of the multiport valve, one relief valve at a time may be removed, tested and replaced.

5. Gaskets and Thread Compounds

Pamphlet No. 58 of the NFPA outlines the various types and weights of pipe and the various types of pipe connections permissible in LP-Gas installations. Manhead gaskets, relief-valve gaskets and pipe-flange gaskets within 20 ft of the tank should be of the dead-soft-aluminum O-ring type or preferably the spiral stainless-steel asbestos-filled type, according to Factory Mutual. The aluminum gasket should not be used on bottom tank connections because electrolysis may result if water should collect at that point. New gaskets should be on hand before any flanged joint is disassembled. Used gaskets should be destroyed.

Proprietary thread compounds for LP-Gas are preferable to the litharge-glycerine mixtures that are combined immediately prior to use. Some sources state that if C.P. anhydrous glycerine is combined with pure yellow litharge, excellent results are obtained. The presence of water in the glycerine lessens the effectiveness of the joint compound. Some pipe fitters prefer to apply compound to the female thread, apparently with the thought that the excess compound will form a sort of gasket which will be forced back into the joint when internal pressure is applied. The overall benefits are negative, because the excess material eventually falls away and may foul a valve seat or an orifice. Compound should be applied only to the male end of the pipe, and then only sparingly.

Applying compound to imperfectly ground joint surfaces of a union is not recommended, as this is a temporary measure at best and will eventually require replacement of the fitting.

6. Painting

Underground pipes and tanks should be protected from corrosion by a suitable bituminous coating or any other coating system that previously has proved effective in the area. Cathodic protection is recommended under adverse soil conditions. Manhole and relief-valve studs should be coated with an inhibited grease coating before applying nuts. Above-ground tanks should be primed with two coats of any good metal primer. The finish coat should be of a light-reflective type. There are several excellent proprietary products available.

D. PURGING LARGE STORAGE TANKS

As stated previously in this report, the flammable range of LP-Gas is roughly between 2 and 10 percent. When an LP-Gas storage tank is emptied and opened, the gas is too rich to burn. If ventilation with air is used to purge the tank of vapors, it is necessary to pass through the flammable range. During this period, any ignition source could cause a violent explosion. Similarly, during the purging-in operation, explosive mixtures would be formed.

Modern purging practice consists of interposing an inert substance. For example, when taking a tank out of service for inspection or repair, the combustible gas content is first replaced by an inert gas or liquid; then this inert material is replaced by air. The process is reversed for purging back into service. The inert gases most commonly used are carbon dioxide and nitrogen, and mixtures of these resulting from carefully controlled combustion of fuel gases, oil, gasoline, etc. Steam and water are also used as intervening media in purging.

There are two distinct actions in purging: Displacement and dilution. If it were possible to displace LP-Gas vapors with an equal volume of inert gas, the task would be simple. However, dilution takes place and the task is made more complex. It may be that four or five times as much inert gas is required because of dilution. Some of the factors affecting dilution are:

1. A large area of contact.
2. A long time of contact.
3. Agitation from high-velocity input.
4. Variation in the specific gravities of the gases.
5. Temperatures of the gases causing convection and affecting specific gravities.

The person entrusted with the responsibility of directing a purging operation should have had previous experience and should be technically competent. To acquire such experience and competence he should observe purging operations which are under the supervision of competent directors of other companies. The LP-Gas system installer or the gas supplier can furnish information on such activities. The American Gas Association has published an excellent book, "Purging Principles and Practice," which ought to be required reading for anyone charged with the responsibility of purging an LP-Gas storage tank. One of the many methods suggested in this publication should be used.

E. HOW TO HANDLE LP-GAS EMERGENCIES

The following recommended procedure is designed to assist firemen, industry personnel or any other interested person in logically approaching and handling an LP-Gas emergency. It is a summary or check list of important steps to take or points to consider in any such emergency.

Obviously, this type of situation is most intelligently handled when the characteristics of LP-Gas and the equipment are known and understood. All fire protection people should become familiar with LP-Gas plant layouts and operation, including the location of shut-off valves, safety devices and general construction of LP-Gas trucks and transports, storage tanks and portable cylinders.

As in any emergency situation, it is of paramount importance to avoid endangering human life in a fire involving or seriously exposing LP-Gas equipment, or serious leakage of LP-Gas without a fire. The basic precautions are:

1. Approach the fire or gas leak from upwind.
2. Keep all persons out of the vapor area. If necessary to evacuate any area which is in the path of the vapor cloud, do so immediately, eliminating all sources of ignition at the same time.
3. Police the area. Keep all persons at least 200 ft away from the area, except those necessary to cope with the condition.

If escaping LP-Gas is not on fire, close any valve available that will stop the flow. Small lines, such as copper tubing, could be flattened or crimped. If an LP-Gas vehicle is involved, consult the driver; or if storage facilities are involved, consult plant personnel regarding possibilities of shutting off leakage.

Water spray is effective in helping to disperse LP-Gas vapor. If available, it should be used as soon as possible, directing the spray stream across the normal path and pushing the vapor into a safe location. Those handling the hose should avoid entering the vapor cloud and should keep low behind the spray so that they will be somewhat protected from radiant heat if the vapor should be ignited unexpectedly.

If a valve is not available to stop the flow of fuel, consider the advisability of igniting the gas to eliminate the spread of the vapor cloud. If it is found desirable to ignite the escaping gas, it must be done from a safe distance, on the upwind side, near the point of leakage and then only after determining that all personnel are in the clear. In many instances, serious hazards would be eliminated if the vapors were ignited and allowed to burn under controlled conditions. The controlled conditions involve application of sufficient water to keep the shell of the vessel and any exposed piping cool so as to allow the fire to consume the product without danger of causing failure of the vessel or piping.

In some instances of leakage from a tank without fire, it may be desirable to move the tank to some remote area free of sources of ignition, where it can leak safely. Such an area may be a blocked-off isolated roadway or an open field. However, if this is to be done, the tank should be moved only in an upright position. It should never be dragged in a manner which might damage valves or piping. Any attempt to turn a tank back upright to move it to some remote locations should be done carefully to avoid damage to valves or piping. As a general rule, an LP-Gas fire should not be extinguished unless the leakage can be stopped immediately.

If the escaping gas is on fire, apply large quantities of water to all surfaces exposed to heat as quickly as possible, approaching the tank from the sides. Concentrate on piping and metal surfaces of the vessel or adjoining vessels, equipment or combustible surfaces exposed to flame or intense radiant heat. Hose holders or monitor nozzles are desirable where continued application of large quantities of water are considered necessary.

Consult driver of vehicle or plant operating personnel (as the case may be) regarding possibilities of shutting off fuel supply. Stopping the flow of gas should be the first consideration.

Dry chemical or CO_2 extinguishers are suitable for small LP-Gas fires, the dry chemical being the most effective. In either case, the extinguishing agent should be directed into the gas stream at the base of the flame.

If the only valve which can be used to stop the flow of fuel is involved in the fire, consider the possibility of effecting shut-off by protecting firemen with water-fog streams and reflectorized suits, or other protective clothing, while they are closing the valve. Proceed slowly to avoid any flashbacks or trapping firemen in the flames.

The controlled burning of escaping LP-Gas (which cannot be shut off by closing a valve) is a commonly accepted fire-fighting practice. The application of sufficient water to keep the shell of the vessel and piping cool will allow the fire to consume the product in the tank without danger of causing failure.

When sufficient water is not available to keep the tank cool, some warning of increased pressure may be noted from the increase in volume of fire or noise level and should serve as a signal that indicates the necessity of moving all men to a safe area.

Failure of LP-Gas tanks usually occurs only when some portion of the metal surface enclosing the vapor space becomes overheated. This softens and weakens the tank to such an extent that it cannot withstand the internal pressure. In the absence of sufficient water to keep the metal surface cool where it is exposed to direct flame impingement or extreme radiant heat, there is danger of the tank rupturing and creating a condition which is commonly described as an explosion, although it is not an explosion in the true sense of the word. Shooting holes in an LP-Gas tank that is involved in a fire does not serve any useful purpose and should not be permitted.

Ordinarily, no attempt should be made to move any tank involved in a fire, as usually little would be gained in reducing the hazard. However, if specific conditions develop that make it desirable to move the tank, it should be moved only in an upright position as stated previously.

If LP-Gas storage vessels or equipment are exposed to serious fires, such as a nearby burning building or fires involving other fuels, it is of prime importance to apply sufficient water to keep the shell of the vessel and the piping cool to avoid any unnecessary release of LP-Gas. If the LP-Gas storage vessel becomes heated to the point of causing the relief valve to function, the discharge should be allowed to burn if it becomes ignited (in some circumstances, as indicated previously, it should be ignited). At the same time large volumes of water should continue to be applied to the vessel and piping for cooling purposes and to allow the relief valve to close after the excess pressure has been relieved. Portable LP-Gas cylinders that are exposed to a serious fire should be moved to a safe location.

Here are the points to remember:

1. Prevent leaks if possible.
2. Eliminate sources of ignition.
3. Shut off gas.
4. If shut off is not possible, flare and control with water.
5. Keep metal and product cool.
6. Police spectators.
7. LP-Gas emergencies can be controlled.

REFERENCES

1. NFPA Pamphlet No. 58—Liquefied Petroleum Gases 1963.
2. Bureau of Explosives Circular 17 and supplements.
3. Bureau of Explosives Pamphlet 24, "Recommended Procedures to Stop Leaks in Domes of LP-Gas Cars."
4. Purging Practices and Principles—American Gas Association.
5. Fire Protection Handbook, Twelfth Edition—National Fire Protection Association.
6. How to Handle LP-Gas Emergencies—Liquefied Petroleum Gas Association.
7. Book III Consumer Storage Appliances Venting—University of Texas.
8. Rego LP-Gas Serviceman's Manual—The Bastian Blessing Company.
9. T. C. George's Tariff 15 publishing Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water.
10. Phillips Petroleum Company Bulletin 370, "Unloading LP-Gas Tank Cars."
11. Phillips Petroleum Company Bulletin 303, "Use of Unfired Pressure Vessels in the Liquefied Petroleum Gas Industry."
12. Liquefied Petroleum Gas Engineering Data—Warren Petroleum Corporation, Tulsa, Oklahoma.

Report on Assignment 8

Methods of Controlling Spillage of Fuel Oil at Diesel Fueling and Unloading Stations

V. C. Barth (chairman, subcommittee), H. E. Graham, W. F. Arksey, R. A. Bardwell, T. W. Brown, P. J. Calza, G. F. Metzdorf, C. F. Muelder, E. T. Myers, H. Parrish, R. D. Powrie, J. C. Roberts, E. R. Schlaf, C. B. Voitelle, J. E. Wiggins, Jr.

Your committee submits the following report on the use of automatic shut-off fueling devices, with particular reference to interchangeability and standardization of connection design.

The Manufacturer's Committee on Automatic Fueling Standardization, in cooperation with manufacturers of automatic fueling systems, was given the opportunity to check combinations of automatic fueling devices of various manufacturers, in the interest of standardization. As a result, the manufacturers have modified their systems (where modification was necessary) to make the nozzles fully compatible to the "cam lobe" fitting, generally considered standard on locomotives.

Interchangeability and standardization of the various types of automatic diesel fueling devices has thus been achieved in the sense that any manufacturer's nozzle will fit any other manufacturer's equipment installed on the fuel tank, without the use of an adaptor. One manufacturer has the automatic shut-off feature totally confined to the locomotive, that is, the tank cannot be over-filled, but any nozzle used with this system must be shut-off manually before disconnecting.

The committee had hoped for complete interchangeability and standardization, but this obviously is not practical from the manufacturers' standpoint. The committee feels that this assignment has now been completed, as all types of automatic shut-off fueling devices have achieved limited interchangeability and standardization, and all types have a history of successful operation in service.

Report on Assignment 12

Water for Battery Use

J. P. Rodger (chairman, subcommittee), R. C. Archambeault, R. A. Bardwell, P. J. Calza, J. J. Dwyer, E. R. Schlaf.

Your committee submits the following specifications for water to be used in both acid and alkaline storage batteries, and recommends that they be adopted and published in the Manual under Part 4.

SPECIFICATIONS FOR WATER FOR USE IN BATTERIES

1. Water to be used for battery replacement water shall be clear and free of precipitated rust and visible sediment.

2. The maximum allowable limits of impurities in the water shall be as follows:

	Parts Per Million	*Grains Per Gallon*
Total solids	125.0	7.3
Fixed solids	75.0	4.3
Organic and volatile	50.0	3.0
Calcium	40.0	2.5
Iron	4.0	0.23
Manganese	0.1	0.06
Nitrates and nitrites	12.0	0.9
Ammonia	5.0	0.3
Chlorides	25.0	1.5

Distilled or demineralized water is preferable; however, water supplies which are frequently analyzed and meet the above criteria may be used without decreasing battery life to any great extent.

Iron produces battery discharge by being oxidized to the ferric condition at the positive plates and reduced to ferrous iron at the negative plates. Manganese, when present, even in small amounts, turns to permanganate and attacks either wooden or rubber separators.

Report of Committee 14—Yards and Terminals

D. C. Hastings, ***Chairman***

H. J. McNally,
Vice Chairman

A. E. Biermann, ***Secretary***
F. E. Austerman
Mike Rougas
W. P. Buchanan
E. H. Cook
F. S. King
G. H. Chabot
B. E. Buterbaugh
M. H. Aldrich

R. O. Balsters
R. F. Beck
H. R. Beckmann
J. A. Bingham
Willard Binzen
W. O. Boessneck (E)
H. M. Booth
R. E. Bredberg
E. G. Brisbin
J. F. Chandler
H. P. Clapp
J. A. Comeau
V. R. Copp
B. E. Crumpler
J. L. Dahlrot
H. M. Dalziel
A. V. Dasburg
G. H. Dayett, Jr.
C. M. Frazier
W. H. Giles (E)
W. H. Goold
H. R. Hall
C. W. Hamilton
I. M. Hawver
Wm. J. Hedley
H. W. Hem
F. A. Hess
J. E. Hoving
V. C. Kennedy
A. S. Krefting
C. J. Lapinski

Fred C. Larsen, Jr.
B. Laubenfels
E. T. Lucey
L. L. Lyford (E)
S. N. MacIsaac
G. W. Mahn, Jr.
A. Matthews, Jr.
C. H. Mottier (E)
B. G. Packard
M. B. Parker
R. H. Peak, Jr.
H. L. Pepper, Jr.
Hubert Phypers
W. H. Pollard
L. J. Riekenberg
L. W. Robinson
H. H. Russell
R. A. Skooglun
E. B. Sonnheim
C. E. Stoecker
T. D. Styles
J. G. Sutherland
Jack Sutton
J. J. Tibbits
L. G. Tieman
J. N. Todd (E)
J. W. Tucker
W. E. Webster, Jr.
W. A. Wood
C E. Zeman

Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 14.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   There are no recommendations for revisions to Chapter 14 of the Manual.

2. Classification yards, collaborating with Committee 16.

   The subcommittee is currently studying the effect of long freight cars on yard and terminal design. Considerable work has been done on this subject, taking into consideration the limits of both horizontal and vertical curves as well as the effect of such freight cars in the operation of hump yards. The study is quite complicated, and is one that must be continued for another year. A final report will be submitted in 1966 as information.

3. Scales used in railway service, collaborating with Committee 18.

   A. Specifications governing the manufacture and installation of electronic track scales.

   Progress report, submitted as information, with the recommendation that the subject be continued, and that the material be submitted for approval and publication in the Manual in 1966 .... page 128

B. Specifications governing the manufacture and installation of automatic, indicating and recording elements for large-capacity scales.
Progress report, submitted as information, with the recommendation that the subject be continued, and that the material be submitted for approval and publication in the Manual in 1966 .... page 137

C. Studies of the accuracies obtained in motion weighing.
Considerable data were accumulated during the year 1964, which are currently being tabulated and studied. Tests will be continued during 1965, the results of which, together with the data that have already been accumulated, will be presented as information in 1966.

D. Coupled-in-motion weighing.
Tests have been conducted on several scales which have been installed at various locations, and the data from these tests have been tabulated. The committee plans to conduct additional tests on other installations during 1965 and present as information a report in 1966.

4. Spot repair facilities for diesel locomotives.
After two years of work the committee was unable to get enough information of importance to present a report as information. It is recommended that the subject be dropped.

5. Integral trains—their effect on existing yards and design of new yards.
Considerable work was completed on this subject, supplementing the report submitted as information in 1964. The committee plans to continue its study and submit another report as information in 1966.

6. Present trends in modernization of yards and terminals in foreign countries.
Final report, submitted as information, with the recommendation that the subject be discontinued .... page 140

7. Factors to be considered in determining the relative merits of various types of yards.
The subcommittee has completed considerable work on this subject, and plans to present a progress report as information in 1966.

THE COMMITTEE ON YARDS AND TERMINALS,
D. C. HASTINGS, *Chairman.*

AREA Bulletin 588, November 1964.

Report on Assignment 3

Scales Used in Railway Service

Collaborating with Committee 18

W. P. Buchanan (chairman, subcommittee), A. E. Biermann, W. Binzen, B. E. Crumpler, J. L. Dahlrot, H. M. Dalziel, G. H. Dayett, Jr., D. C. Hastings, I. M. Hawver, H. W. Hem, F. A. Hess, V. C. Kennedy, A. S. Krefting, F. C. Larsen, Jr., H. J. McNally, M. B. Parker, Hubert Phypers, H. H. Russell, T. D. Styles, J. W. Tucker.

Your committee submits as information the following suggested specifications:

A. Specifications for the Manufacture and Installation of Electronic Railway Track

Scales, and B. Specifications for the Manufacture and Installation of Automatic Weight-Indicating and Recording Devices.

SUGGESTED SPECIFICATIONS FOR THE MANUFACTURE AND INSTALLATION OF ELECTRONIC RAILWAY TRACK SCALES

A. INTRODUCTION

Electronic track scales, as covered by these specifications, include those types of scales employing electrical load cells as the weight-sensing element. They do not cover lever-type scales using load cells to sense the output of the lever system, except with regard to the load cells, instrumentation and electrical requirements not covered in Part 5, Chapter 14, of the Manual. These specifications also cover the electronic scale portion of combination scales employing full load-cell and lever systems where one is mounted over the other. In addition, the specifications are applicable to both static and motion-weighing electronic scales.

These specifications are intended to apply to railway track scales for weighing cars in revenue service. They are further intended to secure reasonable uniformity in scales for similar service without preventing improvement in types of scales or in parts.

For special cases which are not covered in these specifications, the material, workmanship and other qualities should be at least equal to those required herein, and the principles herein set forth should follow so far as they apply.

The prospective purchaser of a track scale should specify a sectional capacity which, in conjunction with the required length, define a scale of sufficient capacity to meet the maximum service requirements, together with such other information as will secure complete and uniform proposals.

AA. CAPACITY AND SIZES

1. Sectional Capacity Defined

The sectional capacity of a scale is the greatest live load which may be divided equally on the load cells of a section without producing stresses in any member in excess of those specified in Sec. BB.

2. Sectional Capacities Standardized

The rated sectional capacity of an electronic track scale shall be one of the following, and shall employ load cells in capacities as shown:

Sectional Capacity (Tons)	*Each Load Cell Rated Capacity (Pounds)*
85	100,000
180	200,000

The rated sectional capacity shall in no case exceed the actual sectional capacity.

3. Scale Capacity Defined

The capacity of an electronic track sale is the maximum live load it will support without developing stresses in excess of those specified in Sec. BB.

4. Permissible Weighing Capacity Defined and Limited

The nominal capacity of an electronic track scale is the greatest weight indication obtainable by the use of all the reading elements in combination. The nominal capacity of a two-section scale shall not exceed the rated sectional capacity. The nominal capacity of a scale with more than two sections shall not exceed twice the rated sectional capacity.

5. Scale Length Defined

The length of a scale is the length of its effective weigh rail.

6. Scale Length—Limits

The effective weigh rails shall not extend beyond the center line of the end sections.

B. PLANS

Assembly plans shall be furnished showing the location of field connections and all information necessary for the purchaser to design and construct the pit and parts not furnished by the manufacturer. Complete electrical plans showing pit connections and detailed instrument wiring arrangements, including component identification and values, maintenance instructions, and any other information pertinent to the maintenance of the weighing system shall be furnished by the manufacturer.

BB. WORKING STRESSES AND FORMULAS

1. General Design Stresses

The bridge design is based on the maximum stresses developed in a single section as the live load moves across the scale. For scales of 85-ton sectional capacity, the dead load may be neglected if it does not exceed 550 lb per ft of track. For scales of greater sectional capacity, allowance must be made for a minimum dead load of 1000 lb per ft of track. For scales of the respective types when the dead load exceeds the limits given, provisions shall be made for the dead load according to the circumstances. The maximum girder bending stresses, as computed by accepted methods, shall not exceed 10,000 psi, this value allowing for the effect of impact by moving loads and other factors.

2. Load Cell Bearing Surfaces

Bearing plates for mounting above and below the load cells shall be of steel hardened to Rockwell C 50–55. For bearing plates in contact with a convex loading surface of the load cell, the minimum thickness of the plate shall be as follows,

Load Cell Capacity (Pounds)	*Bearing Plate Thickness (Inches)*
100,000	2
200,000	2½

3. Concrete Bearing Surfaces

Bearing stresses on concrete shall not exceed 300 psi under load cell bearing plates and 400 psi at all other points.

4. Load Cell Loading

The load cells in a section shall be assumed to carry the sectional capacity equally divided among them.

5. Bearing Pressures Under Foundation

The bearing area of the foundation footings shall be such that settlement or displacement of the foundation will not occur, and soil tests should be made to determine if piles are required.

C. LOAD CELLS

1. Linearity

The output characteristics of a load cell shall be linear within plus or minus 0.1 percent of the "best fit" to the calibration curve representing a plot of voltage output versus load applied.

2. Temperature Characteristics

Load cell characteristics shall be stable with respect to the temperature within the following limits

(a) Zero shift shall not exceed 0.0015 percent of full scale output per degree F.

(b) Span calibration shall not change more than 0.0008 percent per degree F.

3. Overload Characteristics

Load cells should be designed to withstand loads equal to 150 percent of the rated capacity without change in span calibration. They should be able to withstand axial loads equal to 300 percent of the rated capacity without physical failure of the structure.

4. Moisture Protection

Load cells shall be sealed to prevent moisture penetration.

5. Corrosion

Load cells shall be provided with a finish that will be corrosion-resistant under normal pit conditions.

D. CHECKS

1. Design

The checking system shall be designed to hold the weighbridge rigidly in position.

2. Position

Check rods, stay plates or the like shall be set in the same horizontal plane and as high as possible. Longitudinal checks shall be parallel to each other. Transverse checks shall be parallel to each other and be located as close to each section as possible.

3. Strength

The combined longitudinal checks and the combined transverse checks shall be designed to resist anticipated forces.

E. WEIGHT INDICATORS AND RECORDERS

Weight indicators and recorders shall be in accordance with Specifications for the Manufacture and Installation of Automatic Weight Indicators and Recorders, Part 5, Chapter 14.

F. CLEARANCES

The clearance between the fixed and live parts of the scale shall be at least ¾ in, except where other clearances are specified.

G. INTERCHANGEABILITY

Units or parts of units intended to be interchangeable with like units or parts in scales of the same design and manufacture shall be identified on the scale drawings or in the subject matter of the proposal in such a manner as will clearly indicate the interchangable part, the manner of replacement, and the adjustments, if any, after replacement.

H. SCALE WEIGHBRIDGES

1. Types of Girders

Weighbridge girders shall be so designed that the joints over the centers of bearings will admit vertical flexure without displacing the sections.

2. Weighbridge Bearings

The surface of weighbridge bearings intended to make contact with the bridge girders shall be finished so that, when in position, all the bearing surfaces will be within 1/32 in of the same horizontal plane and parallel to it. To secure proper alinement of parts, the diameter of the bolt holes in the weighbridge bearings and the girder shall exceed the diameter of the bolt fastening the bearing to the girder by ½ in.

3. Steel Specifications

Except as otherwise provided herein, structural steel work should be designed and fabricated to conform to AREA Specifications for Steel Railway Bridges, Part 1, Chapter 15.

4. Bracing

Each weighbridge span shall be designed for a lateral force of 200 lb per lin ft, plus 4 percent of the sectional capacity of the scale, uniformly distributed along the top of the weighrail.

5. Diagonal Bracing

Diagonal bracing shall consist of not less than 3-in by 3-in by ⅜-in angles or equivalent. Not less than three diagonals per span shall be used unless otherwise required.

6. Transverse Bracing

To carry the lateral load to the load cells, each span shall be provided at its ends with transverse bracing, for which the section modulus shall not be less than that determined by the formula:

$$S = \frac{1}{4} \quad \frac{(0.04\ C\ \ 200\ L)\ d}{10{,}000}$$

wherein

S is the section modulus, inches^3

C is the sectional capacity, pounds

L is the length of span, feet

d is the distance in inches from the load cell convex loading surface to top of weighrail, or to top flange of girder when pedestals are braced to resist tipping transversely to the girder.

Intermediate transverse bracing shall be used at intervals not exceeding 6 ft and shall have a section modulus not less than that used at the ends of the span.

7. Flange Stiffeners

Not less than one pair of stiffener angles, other than splicing angles, shall be provided over each bearing of the girder in each span of the weighbridge. The ends of these stiffeners shall be milled to fit the fillets of the girder flange.

8. Weighrail Pedestals

The weighrails shall be carried on metal pedestals, except when the design excludes such pedestals, spaced not over 30 in center to center on metal ties or directly on the weighbridge. The tops of pedestals shall be machined. The bottoms of the pedestals shall be machined unless type metal or equivalent is to be poured between the bottoms and the surfaces supporting them. Pedestals shall be designed so that they will transfer the lateral loads specified in Sec. H, Art. 4, to the weighbridge. Tie rods shall be provided to prevent spreading of the weighrails due to the wedging action of the wheel flanges.

9. Fabrication and Assembly

In order to avoid distortion, each pair of weighbridge girders shall be fabricated complete with diagonal and transverse bracing in the shop under proper inspection, where practicable. Where this method is impracticable and where field assembly is necessary, each pair of girders shall be placed in proper alinement and the bracing then introduced and secured.

10. Weighrails—Length and Weight

The weight and section of weighrails shall be as large as is consistent with surrounding yard track conditions. Full length rails should be used.

11. Clearance along Weighrails

The clearance between weighrails, or their pedestals, and the rigid deck shall not be less than 1½ in unless other adequate provisions for clearance is made, and the openings shall be protected from weather and dirt.

I. PROTECTION FROM CORROSION

The finish and treatment of all surfaces shall be durable and appropriate for the intended use.

J. APPROACH RAILS

1. Anti-Creep Provisions

Positive means shall be provided to prevent creeping of approach rails, and to maintain a clearance which shall be not less than ¼ in nor more than ¾ in between the approach rails and the weigh rails, unless some special means is used to reduce impact when wheel loads pass from the approach rails to weighrails.

K. DECK

1. Type

The scale shall be provided with a suitable deck constructed of wood, steel plate or concrete, and may be either a floating or fixed type.

2. Construction

The material for the deck shall be surfaced to conform to safety requirements, and shall be sufficiently strong to support incidental traffic, and shall be waterproof.

3. Clearance

The clearance between the bottom of any fixed beams, or deck supports, and the girder forming the weighbridge shall not be less than 2 in.

L. EXCLUSION OF DIRT AND PRECIPITATION

Means shall be provided to prevent accumulation of dirt, precipitation and other foreign material whereby interference with the action of the scale or undue deterioration of any part of the scale structure might result.

M. LIGHTING

1. Scale House and Deck

Lighting of the scale house and deck shall be adequate for the needs of safe operation and to enable the weigher to observe the weighing instrument, car numbers and position of car wheels with certainty.

2. Pit

The pit shall be provided with sufficient illumination to permit complete inspection of the scale.

N. LOCATION AND ELEVATION

1. Location

Scales shall be so located that an adequate foundation and at least 75 ft of tangent track at each approach to the weighrails can be provided.

2. Elevation

The scale shall be raised with respect to the other tracks of the yard to such an elevation that drainage of the surface water will be away from it. Means shall be provided to prevent water from running into the pit.

O. FOUNDATION AND PIT

1. Material

All scale foundations shall be constructed of reinforced concrete. The quality of materials and methods of mixing and placing the concrete shall conform to AREA Specifications for Concrete and Reinforced Concrete, Part 1, Chapter 8.

2. Dimensions of Pit

The scale pit shall have sufficient depth to afford easy access to all parts of the scale structure. The width between faces of side walls shall be such that there is at least 16 in between the faces of the side walls and the weighbridge girder flanges.

3. Walls of Pit

The side and end walls shall not be less than 12 in thick (preferably 15 in) at the top.

4. Waterproofing

Where necessary to prevent seepage of water through foundations, scale pits shall be membrane waterproofed, or waterproofed by methods equally effective.

5. Drainage

The pit floor shall be pitched to a common point of drainage, and shall be smooth and free from pockets in which water may stand. If the pit floor is below subsurface water level, the pit shall be drained from its lowest point into a sump adequately equipped with automatic means for removal of water as it collects.

6. Approach Walls

Approach walls or piers of concrete shall be built to extend at least 15 ft (preferably 25 ft) from the pit face of the end walls and back under the track to preserve line and surface of tracks. On scales up to 20 ft in length, designed for two-draft weighing, walls shall extend no less than 40 ft ahead of the scale and 50 ft beyond, and grade shall conform exactly to grade of weighrail. They may be built of a solid mass of concrete or may consist of parallel walls or piers; however, the latter construction shall have a single footing supporting both walls. Where necessary to obtain safe bearing capacity, the approach walls shall extend to the same depth as the pit walls.

7. Wall Batter

Wall surfaces next to earth subject to freezing shall be constructed with a batter of not less than 1 to 12.

8. Footings or Piers for Load Cells

Concrete footings or piers supporting load cell base plates shall not be less than 18 in thick. Their tops shall be above the floor a sufficient distance to prevent the accumulation of water around or under the base plates.

9. Pit Floor

The floor of the pit may be a mat of concrete approximately as thick as that required to support the load cell base plates, or if local conditions permit, the thickness may be reduced to not less than 6 in.

10. Anchor Bolts

Anchor bolts embedded in concrete a minimum of 12 in shall be provided in foundations for load cell base plates to match the bolt holes provided for securing the base plates.

11. Deck Beam Supports

For deck beam supports, an effective metal bearing shall be set in, or on each side wall with the center of bearing not less than 3 in from the inside of the pit wall.

12. Ventilation

Scale pits shall be ventilated to meet the needs of each particular case, the object being to prevent condensation on the metal parts.

13. Entrance to Scale Pit

Suitable access to the scale pit shall be provided. The entrance shall be closed by a door suitably fastened to prevent the entry of unauthorized persons.

P. SETTING THE SCALE

The load cell assemblies shall be raised or lowered as required by means of leveling screws, shims or other methods to bring the weighbridge into level transversely and longitudinally. For motion-weighing scales installed on a grade, other means must be employed, such as measuring individual load cell output voltages to insure that the load is properly distributed. After leveling the load cell, base plates shall be grouted as required.

Q. SCALE HOUSE

1. Design

Where a special scale house is required, a suitable and substantial building shall be provided. To insure proper operation of the electronic indicator and/or recorder, year-around temperature control inside the house should be provided.

2. Location

The lateral clearance between the scale house and center line of any track shall not be less than 8 ft, unless otherwise required by law or the purchaser.

3. Indicator-Recorder Shelf

If a shelf is required for mounting the indicator and/or recorder, it shall be so located as to provide for ease of operation without obscuring the weigher's view of the scale deck and approaching cars and to afford ready access to the instrument for maintenance purposes.

R. RESOLUTION SENSITIVITY

1. Definition

The resolution sensitivity of an electronic scale is the minimum change of load on the scale rails required to produce an effective response in the weight indicator.

2. Limit

The resolution sensitivity shall not exceed 50 lb.

S. POWER SOURCE

The power source of the electronic instrumentation and load-cell circuitry shall conform to the following

(a) Voltage: 115 v, ac, ± 10 v.

(b) Frequency: 60 cps, ± ¼ cycle.

(c) The power source must be reasonablly free from harmonics and electrical transients.

(d) Fusing shall be provided at 15 amp unless otherwise specified by the manufacturer.

(e) The power source shall be a separate circuit back to the distribution transformer.

(f) One side of the 115-v power source shall be at ground potential.

T. LOAD CELL CABLING

All cabling between load cells, junction boxes, and electronic instrumentation shall conform to the following

(a) All cables shall be electrostatically shielded.

(b) All cable shields shall be interconnected and carried to a single ground. This should be a separate ground from the power source ground and be provided for the load cells and instrumentation circuits only. It should be a copper rod which, when possible, is driven to the depth of the water table.

(c) The connection between the ground rod and the common ground point of the load cell and instrumentation circuits shall be made with copper wire, or the equivalent, of No. 10 gage or larger.

(d) All cable shields in the load cell circuits shall be grounded at one end only.

(e) All cables shall be insulated with materials having good non-hygroscopic qualities and stable capacitance between conductors.

(f) Load cell cables shall be physically separated from power cables and never run in the same conduit system.

(g) All cable connections, junction boxes, etc., in the load cell circuit shall be properly protected against the entrance of moisture.

(h) All multi-conductor cabling shall be color-coded or provided with other means of identification of the individual conductors.

SPECIFICATIONS FOR THE MANUFACTURE AND INSTALLATION OF AUTOMATIC WEIGHT-INDICATING AND RECORDING DEVICES

A. INTRODUCTION

These specifications are intended to cover all types of automatic indicating and recording devices, mechanically or electrically operated, embodied in or attached to scales.

B. DEFINITIONS

1. An automatic indicating scale is one on which the weights of applied loads of various magnitudes are automatically indicated throughout all or a portion of the weighing range of the scale. A *full-automatic-indicating* scale is one on which the

capacity of the automatic-indicating elements equals the nominal capacity of the scale. A *semi-automatic-indicating* scale is one on which the capacity of the automatic-indicating elements is less than the nominal capacity of the scale.

2. A recording scale is one that is equipped with a device for making a permanent record of the weights of applied loads.

C. CAPACITY

1. The capacity of the automatic-indicating or recording device of a scale shall not exceed the capacity of the weighing system with which it is used.

2. Nominal capacity is defined as the largest weight indication that can be obtained by the use of all of the indicating or recording elements in combination, including the amount represented by any removable weights furnished or ordinarily furnished with the scale.

D. INDICATORS

1. Weight indications may be shown by a pointer or pointers in relation to a circular or fan dial or chart; by a drum revolving under a fixed line; or by means of a visual or printed impression—digital or a display-showing position of an indicating line with reference to a series of graduations.

2. There shall be a definite and clear zero graduation or indication and the indicating elements shall be susceptible of giving an indication on either side of the zero graduation or indication sufficient to show clearly an out-of-balance condition. Provision shall be made by which the zero-load balance may be adjusted. If loose material is used for this purpose it shall be securely enclosed. The balance ball or equivalent device shall not be rotatable and shall be actuated by a self-contained screw, unless the balancing device is motor controlled or is otherwise automatic in operation.

3. The total value represented by all unit weights or range steps in use at any time shall be automatically indicated on or adjacent to the reading face and the printed record.

E. GRADUATIONS OR DIGITAL INCREMENTS

Graduations or increments normally will be in pounds, or fractions thereof. Dials or charts shall be divided with clear, actual or projected intervals of not less than 0.04 in. Where weight values are shown or printed in digital form, the minimum height of figures shall be ⅛ in.

Minimum graduations or digital increments shall be as follows:

1. Not greater than 100 lb for electronic track scales.
2. Not greater than 100 lb for track scales equipped with a dial or reading face or by means of a printed impression from a device relaying information from the dial or reading face.
3. Not greater than 200 lb for a railroad track scale equipped with a mechanical recording device which prints a weight indication from graduations located on the face of or on the rim of a wheel, without means of reading the said indications more closely than the value of one graduation.
4. Not greater than 20 lb for motor truck scales.
5. Not greater than 20 lb for motor truck axle-load scales.
6. Not greater than 1/10 percent of the nominal capacity for built-in, self-contained and portable scales.

F. DAMPING DEVICE

An automatic indicating device shall be equipped with an effective dashpot or other type of damping element, designed to bring the indicating elements quickly to rest.

G. LOCKING DEVICE

A locking device shall be provided on a mechanical scale which will prevent the transmission of force from the platform to the automatic indicating elements when the scale is not in use. The locking device shall be substantial and effective and shall be controlled by means conveniently located outside the housing.

H. SPRINGS

Springs when used with automatic weighing devices shall be of material which will not corrode, and which is not affected by normal ambient temperature changes.

I. CAMS AND SECTORS

Cams and sectors shall be made of noncorrodible material, and contact surfaces for tapes must be accurately shaped.

J. TAPES

Tapes shall be made of stainless steel or other corrosion-resistant material, and shall be uniform in size and thickness throughout their effective length.

K. POISES, TARE AND CAPACITY BARS

Poises shall have exterior shells made of corrosion-resistant metals or alloys. All movable elements forming a part of a poise shall be so constructed as not to be detachable without manifest mutilation of the poise. Tare and capacity bars shall be provided with a stop to prevent movement of the poise back of the zero graduation.

L. UNIT WEIGHTS

Unit weights shall be adjustable, and securely and properly sealed. The unit-weight mechanism shall be constructed to apply or remove weights one at a time, and shall be rapid and positive in its operation and shall function properly irrespective of the speed of operation.

M. PENDULUM WEIGHTS

Pendulum weights shall be constructed of corrosion-resistant metal, accurately fitted to supporting members and so mounted thereon that their position in relation to the fulcrum of the pendulum can be adjusted. Means must be provided to lock the weight in position.

N. ACTUATING ELEMENTS

Racks, pinions and gears shall be accurately made of corrosion-resistant materials.

O. FLEXIBLE CABLES

Flexible cables used in connection with unit weights, extra charts, etc., shall be so constructed that there will be a minimum of back lash, and that adjustments, when required, may be readily made.

P. CHAINS AND SPROCKETS

Chains and sprockets in unit-weight assemblies, etc., shall be so mounted as to be accessible for cleaning, lubrication and adjustment.

Q. INDEX FINGERS AND WHEELS

Indexing fingers, wheels in printers, etc., shall be of corrosion-resistant material, susceptible of adjustment and positive in their action.

R. ADJUSTMENTS

Adjustable parts (other than those for zero load indication) of automatic-indicating elements shall be securely held in place and shall not be adjustable from the outside of the unit housing.

S. TOLERANCES

Tolerances applicable to automatic indicating devices shall be as set forth in National Bureau of Standards Handbook 44.

T. HOUSING OR CABINET

All units composing automatic indicating and recording equipment shall be contained in suitable housing of substantial construction.

Report on Assignment 6

Present Trends in Modernization of Yards and Terminals in Foreign Countries

G. H. Chabot (chairman, subcommittee), F. E. Austerman, R. F. Beck, A. E. Biermann, J. A. Bingham, W. O. Boessneck, R. E. Bredberg, E. G. Brisbin, J. F. Chandler, H. M. Dalziel, A. V. Dasburg, W. H. Goold, D. C. Hastings, C. J. Lapinski, B. Laubenfels, G. W. Mahn, Jr., H. J. McNally, H. L. Pepper, Jr., E. B. Sonnheim, C. E. Stoecker, J. G. Sutherland, Jack Sutton, J. J. Tibbits, W. A. Wood.

Your committee submits as information the following report on present trends in the modernization of yards and terminals in foreign countries, with the recommendation that the subject be discontinued. This report supplements a similar report presented last year (Proceedings, Vol. 65, 1964, pages 161 to 165, incl.) covering installations in Great Britain, France, Algeria and India.

This report includes trends and new yard and terminal facilities in Belgium, Czechoslovakia, England, France, Spain and Switzerland.

BELGIUM

Ronet yard, located near Namur on the Jeumont–Herbesthal line, is an automatic classification yard with its main components arranged in series covering a distance of two miles. The yard includes a 16-track receiving yard, hump, 37 classification tracks, a forming and grouping yard having 8 tracks and an 11-track departure yard. All of these yards are electrified in part, except the receiving yard which is entirely electrified.

Classification is controlled by a complete electronic and automatic system through perforated tape and teleprinter-receiver equipment.

Ronet yard has major and modern shops for car repair and maintenance, and features combined facilities for maintaining and servicing steam, electric and diesel locomotives.

CZECHOSLOVAKIA

The Czechoslovakian Railways are concentrating on a program to reduce the freight handling of several small LCL terminals into a lesser number of terminals not only to expedite delivery of merchandise but also to increase car utilization. The program includes full installation of mechanical means of handling merchandise for door-to-door transports and for transhipment centers; 80 to 90 percent mechanization is expected to be attained by the end of 1965.

ENGLAND

1. Liverpool's Wavertree Freight Depot was constructed to handle LCL freight originating from or destined for the metropolitan area. This facility has replaced 48 stations, serves an area with a 72-mile perimeter, and is equipped to collect, handle and deliver all types of merchandise, except newspapers, perishables and livestock. The main structure, 480 by 180 ft, is a two-bay steel frame building served by 5 tracks, each having a 16-car capacity; along the receiving platform there is a 400-ft conveyor belt operating at speeds from 80 to 120 ft per min and discharging on a transverse conveyor where primary sorting is done. After the primary sorting the parcels are transported by electric trucks to the final sorting area. This installation includes offices, lunch and locker rooms and facilities for delivery-truck maintenance.

2. Cannon Street Station, London, is being rebuilt because the building and roof had been badly damaged by bombing. The British Railways are taking this opportunity to lengthen the platforms, modernize the passenger concourse, build underground parking facilities and utilize its air rights by erecting a 15-story office building over part of the station. Completion is scheduled for June 1965.

FRANCE

1. The Paris–Bercy merchandise-handling facilities, located in Paris, consist of three separate and distinct units constructed as a joint venture between the National Railways (SNCF) and three individual firms which had outgrown other railway facilities they had used in the past. These units were constructed in three stages: the first unit, designed to handle aluminum products, consists of a sheltered dock 500 by 65 ft served by two tracks with a combined capacity of 20 cars; the second unit, which handles canned goods, is a 720- by 65-ft building with a track along one side with a capacity of 18 cars and with another 6-car-capacity track inside the building; the third unit, which is the largest of the three, has been designed to handle general import-export merchandise. The main building of the latter unit covers a 720- by 500-ft area, is served by seven 10-car tracks and has facilities for docking 100 vans or trucks at the street end of the building. Merchandise is handled on dollies pulled by electric robot tractors guided and controlled by an induction system of electrical circuits imbedded in the floor. This conveying system is fully automatic, and the tractors operate from a coded routing inserted in the tractor. To date this system is in use only in Continental Europe, except for one similar installation in England.

2. The National Railways have expanded its marshalling yard facilities throughout the country. Some of the notable improvements are the following: On the Eastern Region, a new yard at Woippy and major extension of Audun-le-Tiche yard; on the Western Region, Trappes yard has been extended; and on the Mediterranean Region, major improvements have been made to the Avignon–Champfleury yard.

SPAIN

This nation's prime concern is the continuous increase of its passanger traffic; 40 stations have been enlarged in recent years to accommodate this expansion.

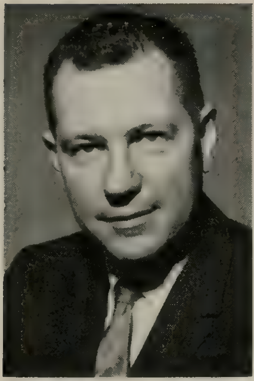
Two of the major classification yards, Hospitalet and Mingorria yards, have recently been fully mechanized.

SWITZERLAND

The Bern passenger station is presently going through a complete reconstruction, the work being done in three stages under traffic, which includes some 1000 switch movements per day. The first stage of construction, completed in 1962, consisted of excavation, drainage and the tunneling of 8200 ft of access hallways leading from the future passenger concourse to various points in the station and on the platforms. Stage two, now in progress, involves the construction of two new platforms and reconstruction of four existing platforms, all covered by a larger mail and express handling facility and a public parking ramp capable of handling 500 automobiles. The last stage, scheduled to be completed by 1967, will involve surface construction comprising the main passenger concourse, offices, gardens, a post office and several commercial buildings.

In addition, the Souleure-Bern station, which handles 8 million commuters annually, will be closed, and its traffic will be handled at the main Bern passenger station after facilities to be located under the latter station are completed. Work is now in progress in the tunnelling of a line through the mountain adjacent to the Bern station and of an area under the station proper for two platforms serving four tracks.

Report of Committee 16—Economics of Railway Location and Operation



T. D. Wofford, Jr.,
Chairman
A. S. Lang,
Vice Chairman
C. W. Sooby, *Secretary*
R. L. Gray
T. D. Kern
L. E. Ward
L. P. Diamond
W. J. Dixon
H. L. Woldridge
G. S. Sowers
M. B. Miller
G. G. Alison
Q. K. Baker
J. W. Barriger
G. A. Bennewitz, Jr.
C. H. Blackman (E)
D. E. Brunn
H. S. Bull
W. G. Byers
J. L. Charles
C. P. Chitwood
H. B. Christianson, Jr.
P. J. Claffey
L. A. Durham, Jr.
G. B. Dutton, Jr.
A. J. Gellman
S. B. Gill
G. E. Hartsoe
L. W. Haydon
H. C. Hutson
G. A. Jacob
H. J. Kay
F. A. Koomanoff
T. J. Lamphier
R. J. Lane
R. F. Lark
H. A. Lind
J. C. Martin
Raymond McCann
C. J. Meyer
R. L. Milner
T. C. Nordquist
F. N. Nye
J. F. Partridge
J. S. Reed
F. J. Richter
V. J. Roggeveen
G. Rugge
A. L. Sams
H. F. Schryver (E)
T. M. Scott
W. P. Shoemaker
L. K. Sillcox (E)
J. J. Stark, Jr.
J. E. Teal (E)
C. L. Towle
F. Wascoe
K. A. Werden
J. R. Wilmot
P. B. Wilson
Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 16.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No report at this time. Committee is obtaining data needed for revision of remaining portion of Manual material, which will be submitted for approval as soon as completed.

2. Study of methods of analyzing the economics of railway engineering projects designed primarily to improve the quality of transportation service.

   Progress report, submitted as information .... page 145

3. Determination of maintenance of way expense variation with various traffic volumes and effect of using such variations, in terms of equated mileage or other derived factors, for allocation of available funds to maintenance of way, collaborating with Committees 11 and 22.

   Progress report, submitted as information .... page 147

4. Potential applications of electronic computers to railway engineering problems in research, design, inventory, etc., collaborating with Committees 11 and 30, and informally with the Railway Systems and Management Association.

   Advance report entitled, "Man-Machine Communications in Civil Engineering" appears as information in Bulletin 587, September–October 1964, page 1.

   Report entitled, "Bringing the Computer to All Engineers," submitted as information .... page 148

5. Engineering methods of reducing time of freight cars between loading and unloading points, collaborating with Car Service Division, AAR, Communication and Signal Section, AAR, Operating–Transportation Division, AAR, and American Association of Railroad Superintendents.

   No report at this time. Committee is preparing a report on information systems and control mechanisms designed for the purpose of expediting freight-car movements.

6. Features of economic and engineering interest in the study, design, construction and operation of new railway line projects, or major line relocations, proposed, in progress or recently completed.

   Advance report entitled, "Construction of the Great Slave Lake Railway," appears as information in Bulletin 587, September–October 1964, page 31.

7. Application of industrial engineering functions to the railway industry.
   Advance report entitled, "An Industrial Engineering Study of a Freight Car Repair Facility," appears as information in Bulletin 587, September–October 1964, page 49.

8. Effects of innovations on the economics of railway location and operation.
   No report at this time. Committee is preparing a report on new operational and engineering concepts that are being studied and on innovations that may be used to meet future competitive situations, reduce cost and improve service.

THE COMMITTEE ON ECONOMICS OF RAILWAY LOCATION AND OPERATION,
T. D. WOFFORD, JR., *Chairman*

AREA Bulletin 588, November 1964.

Report on Assignment 2

Study of Methods of Analyzing the Economics of Railway Engineering Projects Designed Primarily to Improve the Quality of Transportation Service

T. D. Kern (chairman, subcommittee), W. G. Byers, J. W. Barriger, D. E. Brunn, H. B. Christianson, L. A. Durham, Jr., R. F. Lark, R. McCann, P. B. Wilson, J. F. Partridge, J. S. Reed, F. J. Richter, T. M. Scott, K. A. Werden, J. R. Wilmot, T. D. Wofford, Jr.

Your committee submits the following report as information.

The assignment involves defining the quality of transportation service, identifying engineering projects designed primarily to improve quality, determining the appropriate methods of economic analysis and specifying the data required for the analysis.

The quality of transportation service is directly related to those characteristics, both tangible and intangible, that fulfill the needs of the shipper. Some of these characteristics are tied to rates and tariffs and are not subject to engineering treatment. Others are related to equipment availability, to equipment design, to the shipper's loading facilities or to the consignee's unloading facilities and would not normally be the concern of the railway engineer. The characteristics usually involved in engineering projects are total transit time; dependability of delivery, which can often be improved by reducing transit time; cost of loading or unloading when railroad facilities are used; reduction in loss and damage; the ability to handle oversize loads; and the improvement in equipment availability resulting from decreasing the total transit time.

Several types of projects are undertaken primarily to improve the quality of transportation. Among these are enlargement or daylighting of tunnels to increase clearances; line changes to shorten distance or increase allowable operating speeds; yard improvements to reduce total transit time; grade revisions to decrease slack action in trains or improved control of coupling speeds of cars in yards and with special loading; and unloading or storage facilities. In recent years several railroads have eliminated tunnels with restrictive clearances. The elimination of clearance restrictions has resulted in more direct routes (in some cases the ability to handle the traffic at all) for high equipment, such as tri-level automobile cars, thus reducing total transit time. Line changes to reduce distances or increase allowable speeds also improve the total time in transit. Reducing slack action and improving control of coupling speeds of cars decrease the frequency of excessive impacts and reduce damage to both lading and equipment. Special facilities reduce the cost of loading and or unloading certain commodities.

The purpose of projects to improve the quality of transportation is either to retain traffic that would be lost to competition without the improvement or to capture traffic carried by competitive transportation. The competition may be from another railroad or another mode of transportation, or it may be a matter of market competition between shippers serving the same market from different points of origin. The benefits of these projects will be increased gross revenues rather than savings in costs. It must be remembered, however, that the real benefit of either revenue-generating or cost-saving projects is increasing net revenue, and that the net effect of the project, considering all changes in both costs and revenues, must be the basis for the analysis.

Several methods for analyzing the economics of a project are available. In most cases, the expenditures and benefits will occur at different points in time and, therefore, the method used for economic analysis must take into account the time value of money. The so-called "investor's" or "discounted cash flow" method accomplishes this automatically since it determines what rate of return applied to the present investment will produce the future cash flows. The present-worth method consists in determining the present value of future cash flows. It requires assuming some discount rate equivalent to the time value of money to apply to future cash flows and will either result in a determination of whether the present value of income exceeds the present value of costs at the specified discount rate or a determination, by successive approximation, of the discount rate at which the present value of income equals the present value of cost.

In general, the annual cost method is not applicable to projects designed to improve service, since it requires modification to evaluate the alternative of not making the improvement. If the difference in revenue resulting from the project is considered to be the cost of not making the improvement, the annual cost method can be used. The pay-back method, as it is generally used, does not adequately consider the time value of money for comparing projects with differing useful lives. Methods of analysis are discussed in detail in *Principles of Engineering Economy* by Eugene L. Grant and W. Grant Ireson (The Ronald Press, New York, Fourth Edition 1960).

Certain data are required before the economics of a project can be properly analyzed. These include the initial cost of the project, annual operating and maintenance costs, the cost of removing facilities and income produced from salvage or sale of property at the time the project is abandoned, the revenue to be derived from the project, income tax on the new revenue, income tax credits due to depreciation, the life of the project and, for annual cost analysis or present value analysis with a specified discount rate, the discount rate to be used. The accuracy of the analysis depends on the accuracy of these data which, in many cases, can only be rough estimates. Estimates should be made for all items that enter into the costs or benefits of the project. Although some may not be significant, and accurate figures may not be available for others, the practice of including all items reduces the chance of inadvertently omitting a significant factor and helps define any areas of uncertainty.

The estimate of the initial cost should be routine for the railway engineer; however, the effect of income tax in reducing the cost to the railroad of items chargeable to operation must be considered. All costs and revenues should be stated on the same basis with regard to income tax, preferably after income tax. The estimates of operating and maintenance costs should be based on the volume of traffic anticipated after the improvement. The estimates of traffic volume and revenue resulting from the improvement will frequently have to be furnished by the traffic department. In cases where the improvement is designed to prevent loss of existing traffic or to gain a specific class of traffic, these estimates can be reliable. In cases where the improvement is designed to improve the general traffic level, the estimates may, of necessity, be relatively uncertain.

The life of the project will be either the physical life or the economic life of the project, whichever is less. The economic life can be defined as the period over which the revenue resulting from the project will continue without major improvement or replacement of the project due to its obsolescence. The economic life will be determined by obsolescence or, in the case of a project designed for a specific class of traffic, may be determined by the loss of the traffic due to external causes, e.g., depletion of mineral deposits or termination of operations by a large shipper. Overstating the life of the project will overstate the benefits.

In cases where a specified discount rate is used for comparing various projects with different lives, use of an inappropriate discount rate will distort the comparison. Too high a rate overstates the present value of the project with the shorter life. Too low a rate overstates the present value of the project with the longer life. If too high a discount rate is used for amortizing construction costs, the annual costs will be relatively overstated for the project with the longer life, and the benefits will be relatively overstated for the project with the shorter life. If too low a rate is used, the converse will be true.

In cases where the occurrence of a future event is in doubt, a numerical probability or risk factor can be assigned to the event. This makes a reasonably reliable comparison of projects involving differing amounts of uncertainty possible. The application of this principle is discussed in Robert Schlaifer's *Probability and Statistics for Business Decisions* (McGraw–Hill Book Co., Inc., New York, 1959).

In addition to the two references cited above, the following contain discussions of methods of economic analysis and related topics: *Capital Budgeting* by Joel Dean (Columbia University Press, New York, 1960); *Managerial Economics* by William W. Haynes (Dorsey, Homewood, Ill. 1963); *Optional Investment Decisions* by Pierre Masse (Prentice–Hall, Englewood Cliffs, N. J., 1962); *Management of Corporate Capital* by Ezra Solomon (Free Press, Glencoe, Ill., 1959).

Your committee will report in the future examples of specific projects designed for improving the quality of transportation service.

Report on Assignment 3

Determination of Maintenance of Way Expense Variation with Various Traffic Volumes and Effect of Using Such Variations, in Terms of Equated Mileage or Other Derived Factors, for Allocation of Available Funds to Maintenance of Way

Collaborating with Committees 11 and 22

L. E. Ward (chairman, subcommittee), Q. K. Baker, D. E. Brunn, H. S. Bull, P. J. Claffey, L. P. Diamond, L. A. Durham, Jr., R. L. Gray, G. E. Hartsoe, H. A. Lind, R. L. Milner, C. L. Towle, F. Wasco, K. A. Werden, C. J. Meyer, C. W. Sooby.

This is a report of progress, submitted as information.

This committee developed a formula for the measurement of track maintenance costs affected by use, which appears in the Proceedings, Vol. 64, 1963, page 113. Subsequent analysis has been undertaken to determine the relationship of communication and signal and bridge and building maintenance costs with traffic density. Data were made available from one railroad covering a three-year period and were in sufficient detail to separate costs by accounts and by traffic densities. While analysis of the data support the premise that these costs vary to a lesser extent with traffic density than does track maintenance costs, further study is essential if a quantitative relationship is to be established. For example, the level of investment in facilities is related to traffic density in that for a heavy-density railroad we invest more in CTC, better communications, structures, etc., compared to lighter-density railroads. Once these facilities are installed, however, the influence of changing traffic density is relatively insignificant. Interaction and interrelationship of variables must be considered. The correlation between independent variables affects the relationships with the dependent variable, maintenance of way expenses.

Work is now being done through a cost research project included in Association of American Railroads research, which has the flexibility to include most of these considerations.

Your committee recommends that this assignment be continued.

Report on Assignment 4

Potential Application of Electronic Computers to Railway Engineering Problems in Research, Design, Inventory, Etc.

Collaborating with Committees 11 and 30 and informally with the Railway Systems and Management Association

L. P. Diamond (chairman, subcommittee), C. P. Chitwood, G. B. Dutton, Jr., S. B. Gill, G. W. Guthrie, G. A. Jacob, T. J. Lamphier, R. J. Lane, M. B. Miller, V. J. Roggeveen, George Rugge, J. J. Stark, Jr., F. Wascoe, P. B. Wilson.

Your committee presents as information the following paper by M. D. Sinkoff, entitled, "Bringing the Computer to All Engineers."

Bringing the Computer to All Engineers*

By M. D. SINKOFF

Advisory Systems Engineer, IBM Corporation, New York

In a letter to *Engineering News Record* on October 10, 1963, Professor L. L. Boyd of Cornell University quoted Walter M. Carlson, chairman of the Committee on Electronics and director of technical information of the Department of Defense, as saying, "To anyone who has spent several years in the application of computers to the conduct of engineering work, the most chastening experience is the enormous gulf between what can be done with machine processing and what *is* done by practicing engineers and educators."

The problem is simply one of communication between the engineer and the computer. No one would dispute the fact that computers save time and energy and allow for more economical design while freeing the engineer from the tedium of calculation for the creative work he should be doing. But, because of the complexities of traditional methods of computer programming and the expense involved in preparing programs for engineering design, the computer has been kept out of the hands of a great majority of our engineers. In addition, normal computer methods did not lend themselves to the creative ability of our engineers. The use of "engineering judgment" was not possible since the engineer had no control over the method of solution or the ability to adjust answers based on a "feel" for the design.

---

* Presented at American Association of State Highway Officials Committee on Electronics Meeting, Portland, Ore., October 24, 1963.

The engineer began, therefore, to rely on previously programmed or "canned" solutions. Although this allows for rapid and precise methods of solution and does "free" the engineers, we are faced with the problem of the stereotyping of engineering designs. We are using someone elses solution to an engineering problem of our own, and since no two engineering designs are alike, we normally do not obtain the least possible result.

Recognizing this problem (in man-machine communications) as a great deterrent to the advancement of the civil engineering profession through computer utilization, Professor C. L. Miller, head, Department of Civil Engineering, M.I.T., as consultant to the Puerto Rico Department of Public Roads, and his associates in 1960 and 1961 developed a new and dynamic method of computer use called COGO (for COordinate GeOmetry.)

COGO (now available from IBM as COGO I) allows the engineers to use their experience, judgment and creative ability while solving a problem using the computer. He, in effect, presents his problem to the computer as if instructing a fellow engineer. No programming, in the usual sense of the word, is ever necessary. With COGO I, the engineer does not have to fill out long and tedious input forms as the design sketch itself normally is enough documentation for presentation of the problem to the computer. And, interestingly enough, problems indefinitely long can be solved using the system.

This COGO I represents a major breakthrough in engineering computing. It shrinks and nearly eliminates the time required for the engineer to state his problem to the computer. And, more importantly, it is the means by which engineering management can allow all of their engineers to make efficient use of a computer without great investments in programming and computer training.

In using COGO I, the engineer instructs the computer to solve a problem by describing the procedure to use in solution of the problem. The description of the procedure is up to the engineer. He uses a vocabulary of "commands" called the COGO Vocabulary. The vocabulary, a sample of which is given below, uses normal English (civil engineering oriented) terminology. As he is entering each command through the computer's typewriter, he gives the necessary data and the solution appears immediately on its typewriter.

A Sample of The COGO Vocabulary

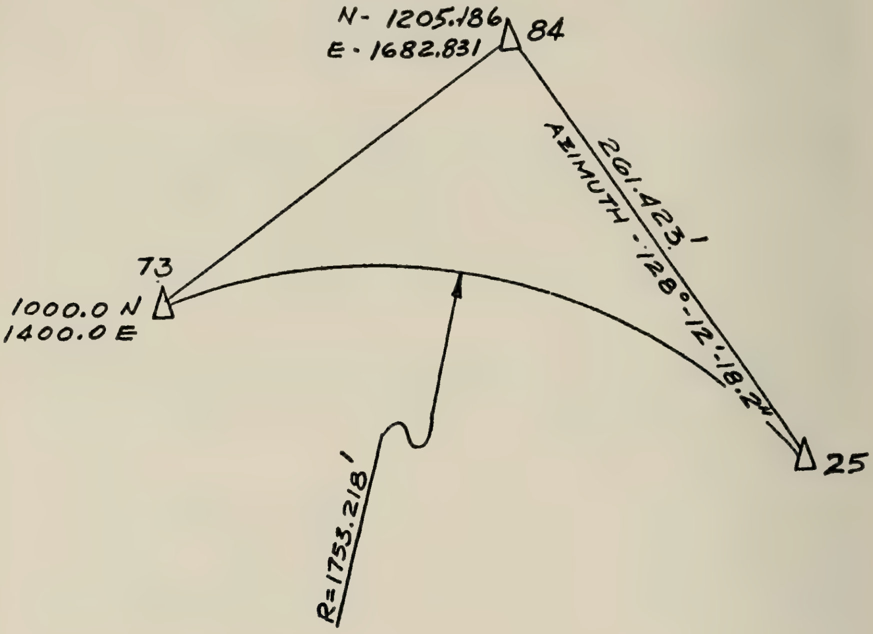
Name (Command)	*Meaning*
STORE	Put known information in the computer.
DISTANCE	Find distance between two points.
ANGLE	Find the angle formed by three points.
LOCATE/AZIMUTH LOCATE/BEARING	Locate a point given a known point and an azimuth (bearing) and distance.
INVERSE/AZIMUTH INVERSE/BEARING	Find distance and azimuth (bearing) between two points.
PARALLEL/LINE	Establish a parallel line to known line.
POINTS/INTERSECT	Find coordinates of intersection of two lines.
ADJUST/AZ/COMPASS	Adjust an azimuth traverse by the compass rule.
AREA	Find the area of a polygon.
SEGMENT	Find the area of a segment of a circle.
ALIGNMENT	Establish the alignment unknowns on a portion of a highway.
OFFSET/ALIGNMENT	Find the coordinates of a point offset from the alignment.
GIRDER/LENGTHS	Find lengths of girders between abutments.
TRIANGULATION	Calculate triangulation net.
ARC/ARC/INTERSECT	Find the coordinates of the intersection of two arcs.

There are 26 other commands in the vocabulary.

COGO I is presently applicable to all types of geometric problems. Using the above vocabulary, the engineer locates unknown points, finds areas, performs alignment calculations, intersects lines and curves, triangulates, finds tangents and angles, adjusts traverses and a host of other frequently performed functions.

Below is a simple problem and the COGO approach to solving it.

The engineer is looking for the distance between 73 and 84, the coordinates of 25, the area of the enclosed figure and the arc length 73 to 25.



First the engineer types into the computer which means store in the computer the coordinates (1000.000 North and 1400.000 East) for point 73.	STORE 73 1000.000 1400.000
He also knows the coordinates of point 84, thus types into the computer	STORE 84 1205.186 1682.831
He wants to know the distance between points 73 and 84, thus he types	DISTANCE 73 84
The computer responds which are the point numbers and the distance between them.	73 84 349.42047
Now he locates the coordinates of point 25 by typing in which means locate using an azimuth, go from 84 to 25 a distance of 261.423 feet and an azimuth of 128° 12′ 18.2″.	LOCATE/AZIMUTH 84 25 261.423 128 12 18.2
The computer responds which are the coordinates of point 25.	25 1043.5017 1888.2578
Now he can determine the area of the polygon 73–84–25 by typing	AREA 73 84 25 73
The computer responds which is the area in square feet and acres.	43940.016 1.0087239

Now the area of the segment between 73 and 25 must be subtracted from the above area.
The command entered is ----------------------

```
SEGMENT/MINUS     73     25     1753.218
```

which are the endpoints of the segment and the radius of the arc through those two points.

The computer responds -------------------------

```
490.19167     491.80251      5631.7985
38308.218     .87943560
```

which is the chord length, arc length, area of the segment in square feet and the net area in square feet and acres.

Thus, in just a few simple commands the engineer has saved himself many minutes of hand computations, has his results before him, has a good feel for his layout and may make modifications or continue, as he pleases. All of this was done without the need for training on computers or computer programming.

The gap between the civil engineer and the computer on geometrical problems has been eliminated by COGO. Through the use of this dynamic method every engineer doing these types of computations should now be able to make efficient use of the computer, saving vast amounts of time for true engineering work. In large highway departments, it is now feasible to have engineers in remote district offices communicating through a typewriter terminal and over telephone lines directly with a central computer and receiving answers in seconds to complicated geometrical problems without programming and while the field work is in process. We see, in the near future, many engineers simultaneously using the centralized computer from remote locations. These engineers may never see the computer, but they will have full access to it, in their own professional terminology, always available to them by simply dialing a telephone and keying in their problem on a typewriter keyboard.

But tele-processing and time sharing are not the only answers for bringing the computer to all the engineers. As COGO has mostly eliminated the cost of programming in highway and structural geometry, and since COGO is operable on quite inexpensive computers (about $12 per hr, for example, on the IBM 1620) multiple small computers located in district highway offices are a practical and economical way to allow engineers to practice their profession in the most professional manner possible.

Report of Committee 20—Contract Forms

J. L. Perrier, *Chairman*

C. L. Gatton,
Vice Chairman

W. F. Burt, *Secretary*

K. J. Silvey
E. A. Graham
F. M. Jones
C. W. Smith
F. B. Mallas
J. D. Taylor
J. T. Evans
J. C. Miller
J. J. Baffa
H. F. Brockett (E)
R. F. Correll
A. B. Costic
J. F. Halpin
E. M. Hastings, Jr.
R. C. Heckel
A. F. Hughes
W. P. Jones
W. D. Kirkpatrick
J. S. Lillie (E)
L. W. Lindberg
D. F. Lyons
W. G. Nusz (E)
G. W. Patterson (E)
W. B. Small
J. L. Southard
W. R. Swatosh (E)
D. S. Taylor
W. B. Tittsworth, Jr.
J. W. Wallenius
D. G. West
H. L. Zouck

Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 20.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Brief progress report, presented as information .... page 154

2. Form of agreement covering purchase and application of weed-control chemicals on railway property, collaborating with Committee 1.
   Progress report, with recommendation that it be submitted for adoption and publication in the Manual .... page 154

3. Form of agreement for lease and operation of rail-trailer terminals.
   Brief progress report, presented as information .... page 158

4. Form of agreement to cover disposal of surplus railway facilities.
   Progress report, presented as information .... page 158

5. Form of lease for railway property used for unloading, handling, and storing liquefied petroleum gases, anhydrous ammonia, and other flammable or dangerous materials.
   Progress report, with recommendation that it be submitted for adoption and publication in the Manual .... page 161

6. Form of agreement covering reimbursement for preliminary engineering expenses.
   Progress report, with recommendation that it be submitted for adoption and publication in the Manual .... page 164

7. Bibliography on subjects pertaining to contract forms.
   Brief progress report, submitted as information .... page 165

8. Form of agreement to cover lease of railway company machinery, tools and materials to other than railway companies.
   Brief progress report, submitted as information .... page 165

THE COMMITTEE ON CONTRACT FORMS,
J. L. PERRIER, *Chairman*.

AREA Bulletin 588, November 1964.

Report on Assignment 1

Revision of Manual

K. J. Silvey (chairman, subcommittee), E. M. Hastings, Jr., A. F. Hughes, W. D. Kirkpatrick, J. D. Taylor.

Your committee has again reviewed the material contained in Chapter 20 of the Manual. While there are a few revisions that might be recommended, they are of an editorial nature and not of sufficient importance to warrant the expense of reprinting the pages necessary.

The study will be continued.

Report on Assignment 2

Form of Agreement Covering Purchase and Application of Weed-Control Chemicals on Railway Property

Collaborating with Committee 1

E. A. Graham (chairman, subcommittee), J. F. Halpin, A. F. Hughes, W. P. Jones, D. F. Lyons, J. L. Southard, W. B. Tittsworth, Jr.

A Form of Agreement Covering Purchase and Application of Weed-Control Chemicals on Railway Property was presented for review and comment in Bulletin 581, November 1963, pages 179 to 182, incl. The suggestions received have led to numerous revisions in the original form, and the revised form, under the new title, "Form of Agreement to Cover Chemical Control of Vegetation on Railway Property," is presented below for adoption and publication in the Manual in part 7, Chapter 20, beginning on page 39.

FORM OF AGREEMENT TO COVER CHEMICAL CONTROL OF VEGETATION ON RAILWAY PROPERTY

THIS AGREEMENT, made this .... day of ...., 19 ...., by and between ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the Railway Company, and ...., a corporation organized and existing under the laws of the State of ...., hereinafter called the Contractor.

WITNESSETH: That, in consideration of the covenants and agreements herein contained, to be performed by the parties hereto, and of the payments hereinafter provided, it is mutually agreed as follows:

1. Supply

The Contractor shall furnish the necessary chemicals, application equipment and labor, where needed to be used for the control of ....
.... at
locations to be mutually agreed upon in such manner as shall be approved by the Railway Company.

2. Shipment of Chemicals and Delivery of Equipment

The Contractor shall ship the necessary chemicals and deliver the required equipment in order to start application between ...., 19 ...., and ...., 19 ...., and agrees to prosecute the work diligently so that application of chemicals can be completed at the earliest possible date, but in no event later than ...., 19 .....

3. Application

The Railway Company will furnish at its own expense work-train service if necessary for the application of the chemicals. The Contractor shall furnish at his own expense the services of a competent supervisor to direct application of chemicals furnished by the Contractor to the Railway Company's property as instructed by and at locations specified by .... of the Railway Company or his representative and in such manner as not to unreasonably interfere with the normal use and operation of the tracks on property of the Railway Company.

The Railway Company agrees to cooperate with the Contractor in every way to prosecute the work diligently and continuously by furnishing work-train service on all suitable work days, provided always that Contractor shall not be required to apply chemicals under weather conditions deemed unfavorable by the Contractor or his representative, or in the vicinity of crops or other areas susceptible to damage from the chemicals being used.

In addition to furnishing all work-train service necessary for applying chemicals on its property, the Railway Company agrees to furnish all necessary water for dilution, free transportation on its lines, insofar as it may lawfully do so, for representatives of the Contractor while engaged in work pertaining to application of chemicals, and free transportation on its lines for all tools, equipment, supplies and materials required for carrying out the work.

After completion of the work, all equipment and tools furnished by the Contractor shall be promptly returned to him, free of charge, at such location on the line of the Railway Company as the Contractor may direct.

4. Maintenance of Equipment

All equipment furnished by the Contractor shall conform to the standards for freight cars prescribed by the Association of American Railroads, and Contractor agrees to bear the cost of its maintenance and repair, except as such maintenance and repair is made necessary by reason of the fault or negligence of the Railway Company or arising out of accidents in the operation of trains.

5. Prices

In consideration of the completion of the application work as described herein, and the fulfillment of all stipulations of this agreement to the satisfaction and acceptance of the .... of the Railway Company, the said Railway Company will pay or cause to be paid to the Contractor the amount due, based on the following prices:

(Here insert a schedule of Items and Prices)

6. Laws and Ordinances

The Contractor shall comply with all federal, state, municipal and local laws, ordinances and regulations in any way pertaining to the application of the vegetation-control chemicals.

7. Unemployment and Retirement Legislation

The Contractor shall accept full and exclusive liability for the payment of any and all contributions or taxes for unemployment insurance or old age retirement benefits, pensions and annuities now or hereafter imposed by the Government of the United States or of any State thereof, which are measured by the wages, salaries or other remunerations paid to persons employed by the Contractor on the application work, and shall comply with all administrative legislation respecting the assumption of liability for the aforesaid contributions, and shall reimburse the Railway Company for any of the aforesaid taxes or contributions which, by law, the Railway Company may be required to pay.

8. Sales and Use Taxes

The Contractor shall be responsible for and pay all sales and use taxes properly assessed, under any federal, state or local law in effect at the time this agreement is executed against any materials, tools, supplies, services and equipment furnished directly by the Contractor and used in the carrying out of the application work. An adjustment of the cost will be made for any changes in such taxes during the progress of the application work.

9. Patented Devices

In case the Contractor shall make use of or employ any patented devices or appliances either for carrying on the application work or in connection with the chemicals or other materials supplied, he shall satisfy all claims or charges for lease, privilege or royalty, and shall at his expense defend the Railway Company against any and all claims or suits which may arise from any infringement of patent rights, and indemnify and save harmless the Railway Company against any judgment of recovery as a result thereof.

In the event any claims or suits are brought against the Railway Company from any infringement of patent rights, Railway Company will immediately transmit to Contractor the name and address of the claimant, the nature of the claim, and such other data that are applicable to such claim.

10. Indemnity

The Contractor shall indemnify, protect and save harmless the Railway Company from and against all losses and all claims, demands, payments, suits, actions, recoveries, legal expenses and judgments of every nature and description made, brought or recovered against it by reason of the negligence of the Contractor or the negligence of Contractor's employees in the execution of the work. The Contractor shall accept responsibility for the damage to the property of any person, firm, corporation, municipality, or government agency resulting from Contractor's application of chemicals furnished by Contractor to Railway Company's property, provided Contractor's representatives are permitted to discontinue application of chemicals under weather conditions which they deem unfavorable and to discontinue application of any type of chemical in territories having susceptible crops in the vicinity of Railway Company's property. In the event any damage to the property of any person, firm, corporation, municipality, or government agency results from Contractor's application of chemicals furnished by Contractor to Railway Company's property, Railway Company will upon receipt of notice of any such claim, demand, or action, immediately transmit to Contractor the name and address of the claimant, the nature of the claim, and such other data that are applicable to such claim.

11. Delays

This agreement is made subject to delays and inability to deliver or accept delivery arising out of priorities, governmental restrictions, shortages of raw materials or railroad cars hereunder, or due to war, strikes, lockouts, fire, flood, the elements, unstable weather conditions or other acts beyond the control of the parties hereto.

12. Payment

All payments for material and application charges incurred under the provisions of this agreement shall be due and payable upon receipt of invoices therefor.

13. Annulment Without Fault of Contractor

The Railway Company shall have the right at any time to annul this agreement upon giving .... days written notice to the Contractor, in which event the Contractor shall be reimbursed for the work done by him under this agreement up to the time of such annulment; the intent being that an equitable settlement shall be made with the Contractor.

14. Arbitration

In case any question arises under this agreement or concerning the subject matter thereof, upon which the parties hereto cannot agree, such question shall be settled by a sole, disinterested arbitrator, to be selected jointly by the parties to this agreement, and if they fail to select such arbitrator within .... days after demand for arbitration is made by either party hereto, then such arbitrator shall be appointed by the judge of the .... Court of ....

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as determined by the arbitrator.

15. Assignment

This agreement shall not be assigned or in any manner transferred by the Contractor without the written consent of the ....
of the Railway Company.

16. Term

This agreement shall terminate ...., 19 ....., except as to any liabilities which might have accrued prior thereto under the terms of this agreement.

In Witness Whereof, the parties hereto have executed this agreement in ....
...., effective the day and year first above written.

Witness: .... Company
.... By ....
Witness: .... Contractor
.... By ....

Report on Assignment 3

Form of Agreement for Lease and Operation of Rail-Trailer Terminals

F. M. Jones (chairman, subcommittee), J. J. Baffa, H. F. Brockett, A. B. Costic, J. F. Halpin, W. P. Jones, W. D. Kirkpatrick, J. L. Southard, J. W. Wallenius, D. G. West, H. L. Zouck.

Your committee has been assembling basic data on this subject and expects to be able to present a comprehensive form of agreement in the near future.

Report on Assignment 4

Form of Agreement to Cover Disposal of Surplus Railway Facilities

C. W. Smith (chairman, subcommittee), J. D. Taylor, J. J. Baffa, H. F. Brockett, R. C. Heckel, L. W. Lindberg, W. B. Small, D. S. Taylor, D. G. West.

The original assignment was divided into two phases, the first dealing with minor surplus facilities and the second with major surplus facilities. The first phase has been completed, and a Form of Agreement to Cover Disposal of Minor Surplus Railway Facilities has been adopted and now appears in Chapter 20 of the Manual on page 20–5–37.

In its work on the second phase of the assignment, the committee has developed a Form of Agreement to Cover Disposal of Major Surplus Railway Facilities, which is presented below as information. Comments and criticisms are invited.

FORM OF AGREEMENT TO COVER DISPOSAL OF MAJOR SURPLUS RAILWAY FACILITIES

THIS AGREEMENT, made this .... day of ...., 19 ....., by and between .... Railway Company, a corporation duly organized and existing under the laws of the State of ...., hereinafter called the Seller, and ...., hereinafter call the Purchaser.

Witnesseth:

Whereas, the Seller does hereby agree to sell and the Purchaser desires to purchase certain facilities as outlined on the attached schedule marked "Exhibit A", dated ...., and at the location shown on the attached print, marked "Exhibit B", dated ...., which exhibits are made a part of this agreement;

Now, Therefore, in consideration of the payment of $.............., the receipt of which is hereby acknowledged, and of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

1. Grant

The Seller hereby grants to the Purchaser, insofar as it has the power to do so, the right and privilege to enter upon the property of the Seller to remove the facilities to be sold, and the Purchaser agrees not to grant or permit any person or persons other than his agents, servants or employees, to enter upon the property of the Seller.

2. Removal

Purchaser agrees to remove said facilities at his sole cost and expense from the property of the Seller by not later than ...., 19 ...., and at such time and in such manner as not to interfere with or endanger the operations or property of the Seller, or any of its agents, servants or employees, and the time and manner of such removal shall be subject to the approval of the .... of the Seller or his authorized representative.

3. Permits

Purchaser shall, at his sole cost and expense, obtain all necessary permits and comply with all local, state and federal laws, orders, rules and regulations applicable to the dismantling or removal of said facilities from Seller's property and agrees to indemnify and hold harmless the Seller of and from any and all claims, demands, actions, recoveries, judgments, cost or expense in any manner arising from failure of the Purchaser to comply with any of said local, state or federal laws, orders, rules or regulations.

4. Taxes

The amount of present or future sales tax, use tax, excise tax or taxes of similar nature applicable to the sale of said facilities, if there be any such tax, shall be paid by the Purchaser, and the Purchaser shall furnish certificate to the Seller to indicate that such taxes have been paid. In lieu thereof, the Purchaser shall provide the Seller with a tax exemption certificate acceptable to the Taxing Authorities.

5. Utilities and Quasi-Utilities

Purchaser shall, at his sole cost and expense, make whatever adjustments that are necessary to existing water, sewer, gas mains or electrical and communication services as may be affected by the removal of said facilities and restore roadway crossings and waterway openings to a condition at least equal to the condition of the adjacent roadway or channel.

6. Indemnity

The Purchaser shall indemnify and save harmless the Seller from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description made, brought or recovered against the Seller by reason of any act or omission of the Purchaser, or his agents or employees, in the execution of the work, or in guarding same.

7. Insurance

The Purchaser shall at the Purchaser's own expense carry insurance at all times in a company or companies approved by the Seller, covering the liability assumed under this agreement, with limits of not less than $................ for one person and $.............. for one accident for personal injuries or death, and $.............. for property damage for each accident with an aggregate limit of not less than $................, and shall furnish the Seller true original counterparts of such policy or policies and have the Seller's written approval of said policies at least forty-eight hours before starting any work covered by this agreement. Said policies shall provide for notice to the Seller at least .... days in advance of cancellation.

8. Storage of Materials

The Seller will, insofar as it is convenient to do so, permit the temporary storage on Seller's vacant land of materials being removed by the Purchaser but only at such locations and in such manner as approved in writing by the .... of the Seller.

9. Purchaser's Understanding

It is understood and agreed that the Purchaser has, by careful examination, satisfied himself as to the location and nature of the work, the character, quality and quantity of the materials and facilities to be removed and has fully investigated all general and local conditions which might affect the work to be performed under this agreement. It is further understood that no verbal understanding, agreement or conversations between the parties to this agreement or their agents or employees, either before or after the execution of this agreement, shall affect, alter or modify any of the terms or obligations herein contained.

10. Assignment

This agreement shall not be assigned or in any manner transferred without the written consent of the .... of the Purchaser.

11. Successors

This agreement shall inure to the benefit of and be binding upon the parties hereto, their successors and assigns.

In Witness Whereof, the parties hereto have executed this agreement in ...., as of the day and year first above written.

Attest .... Company
Secretary By ....
Attest .... Purchaser
Secretary By ....

Report on Assignment 5

Form of Lease for Railway Property Used for Unloading, Handling, and Storing Liquefied Petroleum Gases, Anhydrous Ammonia, and Other Flammable or Dangerous Materials

F. B. Mallas (chairman, subcommittee), J. J. Baffa, R. F. Correll, A. B. Costic, E. M. Hastings, Jr., R. C. Heckel, L. W. Lindberg, W. B. Small, D. S. Taylor, W. B. Tittsworth, Jr., D. G. West.

Two years ago your committee submitted a report on this assignment as information, which report was published in Bulletin 574, November 1962, with a request for comments and suggestions. A number of comments were received and given due consideration.

Your committee now submits the following form of agreement for adoption and publication in the Manual in Part 5, Chapter 20, following page 20–5–40.

FORM OF LEASE FOR RAILWAY PROPERTY USED FOR UNLOADING AND STORING LIQUEFIED PETROLEUM GASES, ANHYDROUS AMMONIA AND OTHER FLAMMABLE OR DANGEROUS MATERIALS

THIS LEASE, made this .... day of ...., 19 ...., by and between ...., a corpcration organized and existing under the laws of the State of ...., hereinafter called the Railway Company and ...., hereinafter called Lessee.

WITNESSETH:

WHEREAS, the Railway Company owns certain premises situated in ...., County of ...., State of ...., further described as follows: ....
....
in accordance with plat hereto attached, marked Exhibit "A" and dated ....
.........................., 19 ...., and made a part hereof, and

WHEREAS, the Lessee desires to lease said premises from the Railway Company for the purpose of constructing and maintaining thereon facilities for the unloading, storing and handling of ....
and for no other purpose, and

WHEREAS, the Railway Company is agreeable to such lease, construction and maintenance thereon, subject to conditions herein set forth;

NOW, THEREFORE, in consideration of the mutual covenants herein stipulated to be kept by the parties hereto, it is agreed as follows:

1. Term

Lease shall be effective ...., 19 ...., and shall extend to .... 19 ...., unless sooner terminated as herein provided.

2. Rental

Lessee shall pay to the Railway Company a rental of $...................... per ...., payable .... in advance, beginning ...., 19 .....

3. Improvement

Lessee shall, within .... months of the effective date of this lease, begin the construction of said facilities and complete same within .... months of said date according to plans and specifications submitted to and approved by the Railway Company in advance of construction. In event of destruction thereof in whole or part, Lessee shall within .... months thereafter commence the work of rebuilding or repairing and complete same within .... months of said date of destruction.

4. Laws and Regulations

Lessee is permitted to and shall use premises for unloading, storing and handling of ...., which product is of a dangerous and flammable nature, and lighting of premises, pump houses or other enclosures shall be by electricity. Lessee shall comply with all Federal, State and local regulations and ordinances and with all regulations prescribed from time to time by any public authority having jurisdiction or by the Railway Company, relating to the unloading, storing and handling of said product.

5. Clearance

Lessee shall not place or permit to be placed, or to remain, any material, structure or pole or other obstruction within .... feet laterally of the center line of track or within .... feet vertically from the top of rail of any track.

6. Unloading Device

Lessee is permitted to construct, maintain and operate at a point opposite the leased premises near the track serving them, a device for unloading .... from railroad cars, together with pipelines extending from a connection with said unloading device to Lessee's tanks located on said leased premises, said unloading device to be constructed, maintained and operated in a manner satisfactory to the Railway Company, and no portion thereof to be closer than .... feet to the center line of any track when said device is not in use.

7. Condition of Premises

Lessee shall at all times keep the premises in a safe, clean and sanitary condition, and shall not mutilate, damage, misuse, alter or permit waste thereon.

8. Taxes

The Lessee shall pay all taxes, licenses and other charges which may be assessed or levied upon said premises, including improvements thereon, and upon the business of the Lessee upon said premises, or against the Railway Company by reason of occupation or use of said premises by the Lessee.

9. Termination

Either party hereto may terminate this lease at any time, by giving to the other party .... days written notice to that effect. Acceptance of rent in advance by the Railway Company shall not act as a waiver of the right to terminate this lease.

10. Notice

Any written notice given by the Railway Company to the Lessee shall be deemed to be properly served if the same be delivered to the Lessee, or one of the Lessee's agents, or if posted on said premises, or if mailed, postpaid, addressed to the Lessee at the Lessee's last known place of business.

11. Refund

Rent paid in advance for a period extending beyond the termination of this lease shall be refunded to the Lessee, unless such termination shall be on account of violation or non-fulfillment of any of the terms of this lease by the Lessee, or on account of abandonment of said premises by the Lessee, in which case the amount paid as rental shall be retained by the Railway Company.

12. Liability

Lessee covenants and agrees to indemnify, protect, and forever hold harmless the Railway Company from any and all claims, liabilities, and expenses which the Railway Company shall incur by reason of any real or alleged injury (including injury resulting in death) to any person or persons whomsoever (including the employees of the parties hereto), and from all loss, claims liabilities and expenses by reason of any real or alleged damage to or destruction of property (including the property of the parties hereto), arising out of, or in any way attributable to the use of said premises by the Lessee, or in any way attributable to the unloading, storing or handling of said product by the Lessee, regardless of whether or not such injury or damage is caused by negligence of the Railway Company, its agents or employees.

13. Abandonment

The failure of the Lessee to occupy or use said premises for the purpose herein stated for .... days at any one time shall be deemed an abandonment thereof. An abandonment of said premises shall, at the option of the Railway Company, operate as an absolute and immediate termination of this lease without notice.

14. Removal of Improvements

Upon the termination of this lease in any manner, the Lessee shall deliver to the Railway Company the possession of said premises to substantially their former state. Should the Lessee fail, within .... days after the date of termination of this lease, to make such removal or restoration, then the Railway Company may, at its election, either remove said improvement and restore said premises to substantially their former state at the sole cost of the Lessee, or may take and hold the said improvements as its sole property.

15. Forfeiture

Any breach of any covenant, stipulation or condition herein contained to be kept and performed by the Lessee, shall be sufficient cause for the immediate termination of this lease.

16. Renewal

A lawful continuance of the tenancy beyond said term shall be deemed a renewal thereof for the further term of .... to end at the expiration thereof, without further notice; and every further lawful continuance shall be deemed a further renewal for a like term, to end in a like manner, and every renewal or holding over shall be subject to the provisions of this lease.

17. Assignment

This lease shall not be assigned or in any manner transferred, nor shall said premises or any part thereof be sublet, used or occupied by any party other than the Lessee, nor for any purpose other than specified herein, without written consent of the Railway Company.

18. Successors

Until terminated as hereinbefore provided, this lease shall inure to the benefit of and be binding upon the parties hereto, their heirs, executors, administrators, successors and assigns.

In Witness Whereof, the parties hereto executed this lease in ....
...., as of the day and year first above written.

	.... Company
Witness	By ....
	.... Lessee
Witness	By ....

Report on Assignment 6

Form of Agreement Covering Reimbursement for Preliminary Engineering Expenses

J. D. Taylor (chairman, subcommittee), H. F. Brockett, A. B. Costic, J. F. Halpin, W. P. Jones, D. F. Lyons, F. B. Mallas, J. L. Southard, J. W. Wallenius, H. L. Zouck.

A report on this assignment, submitted as information, was published in Bulletin 581, Vol. 65, November 1963, with a request for comments and suggestions. Your committee now recommends that the form of agreement presented in that report be adopted and published in the Manual at the end of Part 7, Chapter 20.

Report on Assignment 7

Bibliography on Subjects Pertaining to Contract Forms

J. T. Evans (chairman, subcommittee), R. F. Correll, E. M. Hastings, Jr., A. F. Hughes, L. W. Lindberg, D. S. Taylor.

Your committee has continued its review of material pertinent to this assignment but has no items to submit at this time.

Report on Assignment 8

Form of Agreement to Cover Lease of Railway Company Machinery, Tools and Materials to Other Than Railway Companies

J. C. Miller (chairman, subcommittee), R. F. Correll, R. C. Heckel, W. P. Jones, W. D. Kirkpatrick, W. B. Tittsworth, Jr., J. W. Wallenius, H. L. Zouck.

Your committee has assembled a large amount of data on matters pertinent to this assignment and has started to draft a form of agreement. It is expected that a complete report will be ready for publication at an early date.

Report of Committee 25—Waterway and Harbors

F. J. Olsen, ***Chairman and Secretary***

G. R. Collier,
Vice Chairman

J. G. Miller
M. A. Michel
J. C. Fenno
J. M. Bates
L. E. Bates
G. W. Becker
W. Binzen
R. L. Bostian
C. D. Curran
B. M. Dornblatt
P. P. Dunavant, Jr.
B. Elkind (E)
W. H. Eschwig
J. H. Fitzpatrick
D. Gullatt
R. T. Haggerstrom
C. E. Helmle
H. F. Kimball
A. O. Kruse
E. S. Laws
Shu-t'ien Li
R. D. Lowery
M. S. Patterson
J. F. Piper
C. L. Robison
A. L. Sams
G. A. Stenstrom
R. C. Tench
R. F. Weir
C. T. Yarbrough
Committee

(E) Member Emeritus.
Members listed in bold-face type are the official representatives of the Engineering Division, AAR, Committee 25.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Study is in progress on the revision of Part 5—Dredging, but no report is presented at this time.

2. Current policies, practices and developments dealing with navigation projects.

   No report.

3. Bibliography relating to benefits and costs of inland waterway projects involving navigation.

   Progress report, presenting eight additional references with annotations .... page 168

4. The use of hydraulic models for the study and resolution of waterway problems.

   Final report, submitted as information .... page 170

6. Planning, construction and maintenance of rail-water transfer facilities.

   Progress report, presented as information .... page 171

7. Relative merits and economics of construction materials used in waterfront facilities.

   Progress report, submitted as information .... page 177

The Committee on Waterways and Harbors,
F. J. Olsen, *Chairman.*

AREA Bulletin 588, November 1964.

Report on Assignment 3

Bibliography Relating to Benefits and Costs of Inland Waterway Projects Involving Navigation

M. A. Michel (chairman, subcommittee), G. W. Becker, G. R. Collier, B. M. Dornblatt, C. E. Helmle, H. F. Kimball, M. S. Patterson, C. L. Robison, G. A. Stenstrom, R. C. Tench.

Your committee submits as information the following additional references with annotations.

1962

1. January 31, 1962. *"Outdoor Recreation for America." A report to the President and to the Congress by the Outdoor Recreation Resources Review Commission, pursuant to Public Law 85–470, commonly known as the Lawrence S. Rockefeller Outdoor Recreation Report, and 27 ORRRC Study Reports. Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.*

Note: Benefits derived or "claimed" due to the many phases of outdoor recreation, which were formerly considered "intangibles," could be the determinant for the financial feasability of a water resource project involving navigation. Fishing benefits could mean anything from $0.50 to $3.00 per visitor day, and hunting benefits from $0.50 to $6.00 per visitor day. (ORRRC Report 24, pages 57 and 58, "Agency Evaluations of Recreation Benefit"—Fish and Wildlife Service). With enough fishermen and hunters, numerous inland waterways might be financially justified which would otherwise be economically unsound.

2. March 1962. *The Report of the U. S. Study Commission, Texas, 87th Congress, 2nd Session, House Document No. 494, Parts 1 to 4, incl.*

This report is the result of a complete investigative study which resulted in the formulation of a comprehensive development plan for land and water resources covering almost 62 percent of the State of Texas. Part II, Chapter 12, entitled "Economics Criteria," includes Table No. 81, captioned "Project Evaluation Procedures," which gives an excellent comparative analysis of such procedures as were in practice by the various Federal agencies and the "commissions" at the time of the Texas study.

Note: The study should be of particular interest to the membership, as Charles D. Curran, currently AAR Director of Waterway Analysis, and a member of Committee 25, headed the executive staff of the study.

1963

3. May 27–31, 1963. *"Seminar on River Basin Planning, Fort Belvoir, Va., 483 pages." Available from Department of the Army, Office of the Chief of Engineers, Washington 25, D. C.*

This single volume includes 45 papers prepared by representatives of the various Federal agencies concerned with river basin planning, many of which involve benefits claimed in connection with water resource projects involving navigation. Appendix A of the seminar volume provides 23 pages of "Selected Bibliography on Water Resources Development" which includes some 235 published volumes or papers, many of which relate to economics.

4. June 19, 1963. *Report of U. S. Study Commission Southeast River Basins entitled: "Plan for Development of the Land and Water Resources of the Southeast River*

Basins." Available from the Commission, Acting Executive Director Clarence M. Conway, 800 Walton Building, P.O. Box 953, Atlanta 1, Ga.

The plan includes almost all of Georgia, the northern portion of Florida, minor parts of Alabama, and South and North Carolina. The report pursuant to Public Law 85–850 (72 Stat. 1090) consists of 12 volumes inclusive of 13 appendixes. Appendix 9—Part Five, Section I: "Cost Sharing and Financing," indicates that the "U.S. Study Commission" under Commercial Navigation has considered that ". . . capital investment will be shared 80 percent Federal and 20 percent non-Federal. Operation, maintenance and replacement costs will be shared 60 percent Federal and 40 percent local for typical projects." This Section also discusses the "Study Commission's" position on cost-sharing principles relative to the varied water and related land project purposes.

5. December 24, 1963. *Congressional Record—Senate (pages 24308–24314 incl.)*

Senator Proxmire, Wisconsin, under the caption: "A Billion Dollars of Taxpayers' Money Down Drain, Economic Expert Shows," introduces a devastating analysis of Federal waste in our huge water resources projects by Professor Robert Haveman of Grinnell College, Iowa. Serious deficiencies are pointed out in the present benefit-cost analysis. Senator Proxmire made the following statement, as a partial summary of the Haveman paper, from the floor of the Senate on December 24, 1963:

> "Professor Haveman has selected 10 States which enjoyed some 147 projects between 1947 and 1962 involving some $2,644 million. He found that applying the evaluation techniques of highly competent economists that 63 of these 147 projects representing $1,169 million of Federal funds or 44.2 percent of the total should never have been undertaken. He charges that these projects have led to a misallocation of national resources and economic waste.
>
> "Think of that, Mr. President, a shocking 45 percent of the billions of dollars we spend on these projects, spent wastefully on the basis of competent, objective, scholarly study. Those who scoff at charges of pork barrel and waste in the Congress should consider this Haveman study very carefully."

The paper is amply footnoted and documented.

Note: The Haveman benefit-cost analysis was also editorialized in the Wall Street Journal of January 17, 1964, under the caption: "A Watery Waste."

1964

6. April 1964. *Redevelopment, Vol. 1, No. 3, issued by U. S. Department of Commerce, Area Redevelopment Administration. Article captioned: "More Resource Projects for Redevelopment Areas," by Victor Roterus (Economic Advisor to the Administrator, A.R.A.).* This article spells out the philosophy of "redevelopment" benefits.

Mr. Roterus states that guidelines have been developed and established whereby, through utilization of the unemployed on projects in areas of chronic and persistent unemployment, "redevelopment" benefits are derived and claimed as credits to the project. He sums the resultant in a single sentence: "The effect of the application of these guidelines to proposed water resource projects will be to give such projects a more favorable benefit-cost ratio when they are located in redevelopment areas." He continues: "Thus redevelopment area projects will henceforward enjoy a higher relative priority than projects in other areas."

Note: These guidelines are now in practice by several Federal agencies. A navigation lock is being constructed into the Cordell Hull Dam project; "the installation is said to be the first of its kind to be justified economically in part (up to 20 percent) under federal depressed area aid." (The Waterways Journal May 2, 1964). Redevelopment benefits could be the determinant for water resource projects which would otherwise be found economically unsound. Thus, depressed areas become blessings for Federal agencies concerned with water resource projects.

7. May 1964. *"Public Investment Criteria," by William I. Davisson, Department of Economics, Sacramento State College, Sacramento, Calif., published in the May 1964 issue of "Land Economics," a quarterly journal published by the University of Wisconsin, Madison 6, Wis.*

The paper examines two aspects of public investment criteria: benefit-cost criteria and the problem of allocating costs in a multiple-purpose project. Relative to benefit-cost analysis, the author concludes as follows: "This study concludes that benefit-cost ratios are inappropriate as a criterion for the evaluation of federal river development projects because the ratios do not show the relation between net revenues and dollar investment, hence cannot comprehend the condition of a limited budget situation. The appropriate criterion is maximization of present worth" (rate of return).

8. July 1964. *"Strategy for Mobility" (249 pages). Authored by Wilfred Owen, published by The Brookings Institution, 1773 Massachusetts Ave., N.W., Washington 36, D.C.*

The chapter, "The Economy of Water Transport," glorifies natural waterways and infers that waterways "have a substantial cost advantage over railroads." (This inference is highly debatable and not proved.) At page 197 the author questions the validity of the use of the benefit-to-cost process in determining the need for and establishment of transport investment, due to broad underlying assumptions which are dependent upon good judgment.

Report on Assignment 4

The Use of Hydraulic Models for the Study and Resolution of Waterway Problems

F. J. Olsen (chairman, subcommittee), Shu-t'ien Li, W. Binzen, C. D. Curran, P. P. Dunavant, Jr., W. H. Eschwig, R. T. Haggerstrom, H. F. Kimball, J. F. Piper, A. L. Sams.

Your committee submits as information the following final report, which was prepared by J. F. Piper.

The present state of hydraulics and hydraulic design techniques is based primarily upon experimental data accumulated over the recent centuries and upon empirical formulas that have evolved from this experimentation. It will be noted that most formulas concerned with fluid flow contain empirical coefficients. It is obvious that hydraulics, as we know it now, is not an exact science. This is particularly true when we attempt to study and predict the hydraulics of nature, i.e., the action of seas, rivers, harbor waters, tides, etc.

Frequently, problems are encountered wherein the quantities and variables are not clearly understood, nor mathematically available. Hence, mathematical calculations would be proportionately unreliable, or even misleading. In these cases the engineer must resort to experimentation.

To attempt to resolve such problems by experimentation in nature (i.e., with the prototype) is obviously a costly and difficult undertaking, one which in all probability could not be economically justified. It is here that the hydraulic model can prove to be a useful engineering tool.

The hydraulic model has been defined as a miniature hydraulic system which will conform to the same physical laws as the prototype, in which the relative cost is small, and in which the factors controlling fluid motion can easily be regulated and observed.

Its purpose is to resolve in a practical way those problems which involve imponderables, and which do not lend themselves to reliable solution by purely mathematical means.

In the railroad industry, the construction, operation and study of a hydraulic model may be economically justified in studies involving the location of harbor, port and river facilities; in the design of the structures and facilities; and in the alteration and/or relocation of existing facilities which may have hydraulic problems, such as excessive silting in pier slips, unacceptable current conditions, structural erosion, etc.

The Corps of Engineers, U. S. Army, has extensive hydraulic model facilities at its Waterway Experiment Station, Vicksburg, Miss., which, to some extent, are available to industry. Several universities (Worcester Institute, Worcester, Mass., and the Massachusetts Institute of Technology, Cambridge, Mass., to name two) build, operate and report on model studies to industry, also.

The use of hydraulic models has become a widely accepted technique that has proven economically justifiable when applied to projects of sufficient magnitude to justify their use, or when the problems are so complex, either in scope or urgency, as to require a clearly defined course of action based on the elimination of all possible variables or intangibles.

Report on Assignment 6

Planning, Construction and Maintenance of Rail-Water Transfer Facilities

J. C. Fenno (chairman, subcommittee), R. L. Bostian, Jr., P. P. Dunavant, Jr., W. H. Eschwig, J. H. Fitzpatrick, C. E. Helmle, E. S. Laws, J. G. Miller, R. F. Weir, C. T. Yarbrough.

Your committee submits as information the following progress report, which was prepared by R. L. Bostian, Jr.

Location Considerations

The ideal site for rail-water transfer facilities is rarely found; in most cases the best available site must be developed carefully. An understanding of the factors involved will aid in the most economical development of such a site. The scope of this report is to present the various factors involved in the location of terminals.

Any proposed expenditure must, at some stage of the project, be economically justified. A valuable tool is the basic railway construction formula: *Gross Revenue minus Operating Expenses divided by the Invested Capital is equivalent to the Rate of Return.* A 20-percent rate of return will yield a 100-percent return in 5 years. A 4-percent rate of return will yield a 100-percent return in 25 years. The larger rate of return justifies a smaller capital expenditure for a given revenue. This formula is useful in determining the maximum capital outlay and also in determining a capital expenditure to eliminate an operating expense.

Geology has a tremendous effect upon development details. Of course, geological features are general in nature, and any site within a given geological area will have similar features. There are four types of coastal features: submerged coasts, risen coasts, neutral coasts and compound coasts.

Submerged coasts are formed by the submergence of the land mass. They are characterized by flooded river basins and deep-cut river channels which extend well out on the continental shelf. Good, deep harbors are thus formed, which require minimum dredging. A good example of a submerged coast is the North Atlantic Seaboard from Chesapeake Bay northward. The submerged channel of the Hudson River can be traced about 125 miles beyond the present mouth of the river. This type of coastal feature accounts for the large number of good deep ports in the New England States.

Risen coasts are formed by the emergence of the land mass. They are characterized by shallow water and uniform beds. Good ports are scarce along a risen shoreline. The Pacific Coast is an example of a rising coast, and extensive dredging is usually required to develop deep-water ports.

Neutral shorelines are caused by natural weathering and erosion. The trend is to establish a shore profile of equilibrium. The economical merits of a neutral coast have to be determined from the site conditions.

Compound shorelines are a combination of any of the other types. A good example is the South Atlantic Coast from North Carolina southward. This coast has the flooded basins of the submerged coast, such as Albemarle and Pamlice Sounds, but it is predominantly a risen coast with large expanses of shallow water. For example, evidence of the sea's original presence is found near Columbia, S. C., at an elevation of about 150 ft above the present sea level, and over 100 miles inland from the present sea coast.

The recent earthquake in Alaska has brought out the importance of the effects of earth tremors. Most of the earthquake epicenters, or centers of disturbance, are located along belts, the greatest of which is called the Circumpacific Belt. The second great belt is the Alpide Belt. Other belts are the Mid-Atlantic Oceanic Belt, the Arctic Oceanic Belt and the Indian Ocean Belts.

In considering the effects of earthquakes, the procedure may be summarized as follows:

1. Determine the seismicity, or the degree of subjection to earthquake, of the region and of the area, including the maximum accelerations and the ground motions to be expected.
2. Determine the importance of various structures in the project and the degree of protection required for each; also the calculated risk values, if applicable.
3. Establish a definite criteria covering lateral forces, factors of safety, unit stresses, and method of analysis for each structure. With these criteria, the structural design can be performed.
4. In the general planning of a project, incorporate as many safety precautions as possible against the hazards of earthquakes. Fault zones should be avoided, and consideration for the effects of the resulting seismic sea waves should be made. The average increase in the cost of an earthquake resistant design ranges from 3 to 5 percent of the total costs.

A phenomenon closely akin to seismism is the effect of explosion. Explosions can be caused by accidental cargo explosions or war bombardment. It is not economically feasible to design ordinary structures to resist the direct effects of explosions. The secondary effects are of greater significance, since it is possible to design structures which will be reasonably resistant to the secondary effects at a moderate increase in cost. There are three secondary effects:

1. Blasts—a wave propagated through the atmosphere caused by the sudden generation and expansion of gases resulting from an explosion.
2. Shock—a wave propagated through any medium or combination of media of an elastic nature. The waves may be of two types, longitudinal (tension and compression), and transverse (shear).

3. Fragmentation—a bombardment by flying fragments propelled by the force of the explosion.

Waves are undulations of the surface of the water of a periodic nature. They may be produced by various causes, such as moving vessels, submarine explosions, barometric fluctuations, earthquakes, the attraction of the sun and the moon, and by wind. Of greatest importance are those caused by the winds and the attraction of the sun and the moon. It is necessary to base the design of harbors on the height of the maximum wave which may be expected to attack any part of the protective works at any stage of the tide. The wind velocity is a factor, but when the velocity becomes excessive, the tops of the waves are blown off, the waves becoming broken and irregular.

In the open sea, experience has shown that the empirical formulas proposed by Stevenson, which contain only a single independent variable, namely the fetch, may be used with reasonable confidence in estimating the height of the critical storm wave for any particular site where long-term records of measured wave heights are not available. These formulas are:

$h = 1.5\sqrt{F}$, used when fetch F is longer than 30 miles.
$h = 1.5\sqrt{F} + 2.5 - \sqrt[4]{F}$, used when fetch F is less than 30 miles.

The fetch is confined to the distance over which the wind acts continuously in one direction. It is probable that the greatest applicable fetch does not exceed 1000 miles. Actual measurements have indicated the following maximum storm wave heights occurring in the open sea: North Sea, 12 to 15 ft; Mediterranean Sea, 15 to 20 ft; Black Sea, 20 to 30 ft; Atlantic Ocean, 30 to 40 ft; Pacific Ocean, 50 to 60 ft.

In the case of inland lakes, a method for determining wave heights has been developed by Committee 1—Roadway and Ballast, and will be presented in the February 1965 Bulletin. This method is based upon the extensive studies of United States governmental agencies.

The impact of waves gives rise to four distinct forces: the direct horizontal force, the vertical force acting upward on any projection, the vertical force acting downward which results from the waves breaking, and the rarefaction and compression of air. The total energy of a deep-water wave during a complete wave period is: $E = w\ L\ h^2/8 \times (1 - 4.935\ h^2/L^2)$, of which one-half is kinetic and one-half potential. The potential energy is transmitted onward with the wave form. The pressure exerted by a wave striking a vertical-faced obstruction can be determined approximately by the Gaillard–Moliter equation for the maximum intensity (p) in pounds per square feet, of the wave pressure striking normally: $p = K\ W/2\ g \times (v + V)^2$ where K is an empirical coefficient (being 1.3 to 1.7 for inland lakes and wind velocities of 30 to 70 mph, and 1.8 for ocean waves), W is unit weight of water per cubic foot, and v and V are velocity of propagation and orbital velocity, respectively, of the wave. For oblique waves, p is reduced in proportion to $\sin^2 \theta$, where θ is the angle between normal to wave crest and the face of the structure. For a completely obstructed wave, the point of application of p is above the undisturbed water level at a height $H = 0.79\ h^2/L$. Observations reveal that the impact of a wave does not resemble that of a solid body: the pressures are due to dynamic action only; the pressures conform to the hydrodynamic laws governing the action of a current flowing normally against a submerged plane; a wave of water in air projected with a certain velocity against a surface can produce no greater pressure than would be caused by a steady flow against this surface by a jet of equal cross section having the same velocity.

When a storm wave passes through a harbor entrance from the open sea, the wave height is reduced in the harbor. This reduction is more pronounced the greater the breadth of the harbor is compared to the width of the entrance and the greater the distance from the entrance. Stevenson's equation, widely used to obtain a fair approximation of wave conditions inside a harbor, is as follows:

$H' = h\,[\sqrt{b/B} - 0.02(1 + \sqrt{b/B}) \times \sqrt[4]{D}]$, where H' is the height of the reduced wave in the harbor, h is the height of the wave at the entrance, b is the breadth of the entrance, B is the breadth of the harbor at the desired point, and D is the distance from the entrance to the desired point. All dimensions are in feet.

In planning structures which are to be exposed to wave action, it is desirable to secure data on the following: frequency and violence of storms, the direction and maximum velocity of storm winds, fetch, the direction of wave travel, the maximum height and length of storm waves, whether or not waves break in advance of or in the vicinity of the site during storms, the governing depth in the vicinity, the configuration and character of the bottom, the fluctuation of the water level, the movement of ice, and the reductive power of the harbor at the site. It is poor practice to erect in sheltered waters works that are heavy enough for the open sea. Mud on the bottom is an indication of sheltered waters. For a thorough treatise on waves, refer to References 2, 3, 4, 6 and 8 at the end of this report.

Currents are created by gravitational flow, tides and prevailing winds. The energy of flowing water creates a scouring force which adheres to the principles of dynamics of fluid flow in open channels. Stevenson gives a practical table of scour, as follows:

Velocity	*Scour*
3 in/sec (0.170 mph) ...	Just begins to work on fine clay.
6 in/sec (0.341 mph) ...	Will lift fine sand.
8 in/sec (0.454 mph) ...	Will lift sand as coarse as lint seed.
1 ft/sec (0.682 mph) ...	Will sweep along fine gravel.
2 ft/sec (1.364 mph) ...	Will roll rounded pebbles 1 in. in diameter.
3 ft/sec (2.045 mph) ...	Will sweep along slippery angular stones the size of an egg.
6.56 ft/sec (4.472 mph) ...	Will scour gravel.

There are two theories concerning the sediment-carrying capacity of streams: the "Tractive Force Theory" and the "Regime Theory." These theories are discussed in "River Training and Bank Protection," Flood Control Series No. 4, United Nations Publication, 1963.

In the Tractive Force Theory, the mean tractive force is proportional to the unit weight of water, the hydraulic radius and the hydraulic gradient. When the tractive force is equal to the resistance of the bed material, it is called the critical tractive force. A greater force will set the bed in motion. The critical tractive force for non-cohesive materials is equal to 0.078 times the mean diameter of the particles, where the mean tractive force is per unit area of river bed and is expressed in kilograms per square meter, and the mean diameter of the particles is in millimeters.

The Regime Theory was developed to prevent silting or scouring in canals. Its equation is: *hydraulic radius in feet divided by wetted perimeter in feet equals slope to the ¼ power divided by 6.25 times the mean diameter of sediment in millimeters.*

Gravitational flow is predominant in rivers and inland bodies of water. A cardinal rule to follow is: "Give due consideration to the character of the river and do not attempt to force the flowing water to performance which is foreign to the nature of the river." The gradient of a river gives it the power of water movement. The practice of "open river regulation" is resorted to in the United States. Tidal currents are important in the lower reaches of a river, which is where the deep-water ports are usually found.

River mouths are classified into two groups: (1) mouths subject to weak tides, and (2) mouths subject to strong tides. Also important is the size of the river and the quantity of sediment carried. In planning improvements in a tidal estuary, a thorough understanding of its tidal regime is a first requisite. This regime is never the same for any two estuaries. The practical approach is a thorough study of data obtained from current-meter measurements, tide-gage records, frequent salinity observations and sediment samplings. Alterations made in estuaries produce changes throughout the entire tidewater area connected to it. Physical features which favor the production of silt in estuaries are: high tides, strong tidal currents, frettings, tidal bores, bars and sand banks, and wide land-locked estuaries.

Ocean currents are examples of wind-produced currents. A very important wind-produced current is the along-shore, or littoral current. These currents play an important role in the behavior of river mouths and wave action.

Both dry and completely submerged sand, if not disturbed by seepage or eroded by flowing water, wave action or wind, will stand to any height at slopes not exceeding their angle of internal friction. But as sands are readily disturbed by seepage and wave action, the slope angles of banks in sand, within the range of normal fluctuations of the water level plus twice the anticipated wave heights, should be no steeper than one-half and preferably one-third the angle of internal friction of the soil.

Waterways of a width less than 15 times the breadth of a vessel and shallower than 20 times its draft affect the movement of the ship through the water. In a restricted channel, where the boundaries of the waterway are the boundaries of the channel, the ratio of the area of channel to the total areas of the midsection of the largest ships that will occupy the channel at one time ranges from 5.4 to 8.6. In an open-water channel, where the waterway extends beyond the boundaries of the channel, the ratio of channel area to ship midsection area usually ranges from 2.6 to 7.6. Channels should be widened at bends, and ample turning and anchorage areas should be provided.

The function of a marine or deep-water terminal is to serve as a transfer point for cargo and passengers between land and deep-draft, large-tonnage ships. Such terminals are located in the sheltered waters of an artificial or natural harbor. Each comprises one or more ship berths, together with cargo handling-equipment, railroad and truck accommodations, covered and open storage space, waiting rooms, office space, and other facilities. Terminals vary with the character and quantity of cargo to be handled. The location of the site depends upon accessibility by rail, highway and water transportation, the ease of docking, cost of development, and the possibility of future expansion. Consideration must be given to established bulkhead and pier lines, municipal or county zoning, and other governmental restrictions. The entrance should be at the seaward end of the project to avoid causing an accumulated wave from forming in the berthing area. The direction of the entrance should, when possible, coincide with that of the heaviest waves to assist in guiding vessels into the harbor. The width of entrance should vary from 100 to 400 ft and upwards. It is desirable that the piers be laid out at an angle of about 12 deg with the direction of the prevalent wind. The entrance should be devised so as not to form a trap for passing shingle and drift. Horizontally convex or polygonal piers are preferable to long, straight piers at right angles to the waves. Special care should be taken to avoid a concave horizontal outline on a structure which confines a wave and produces a dangerous concentration of force. There should be a sufficient distance from the mouth to allow a vessel proceeding under full speed to slow its approach. The trend in modern ships is towards longer, deeper and faster vessels.

The average terminal handles from 100,000 to 200,000 tons annually per berth. Items to be considered are terminal layout, ship berths, terminal capacity, transit sheds, pierside warehouses, cargo-handling equipment, dock aprons, shipside trackage, shed layout, highway truck requirements, lighting and ventilation, fire protection, storage warehouses, railroad requirements, and open storage space.

Railroad yard locations are determined largely by the available land. Yards are usually located away from valuable deep-water frontage in areas of lower land values. Track systems should be planned for fast and economical handling of cargo.

The function of an inland or shallow-water terminal is to serve as a transfer point for cargo and passengers between land and shallow-draft barges and boats. The sites are relatively protected. Some rivers having an excessive water level fluctuation require unusual facilities. One solution is based on the principle of the railroad car float transfer. Where the range of water level is moderate, gangways are provided. Considerations for a deep-water terminal in sheltered waters would be applicable to inland terminals.

For more information concerning port development and location, a number of ready references is furnished below.

REFERENCES

1. Abbott, R. W.: "American Civil Engineering Practice," Vol. II & III; John Wiley & Sons, Inc., New York, 1956.
2. Beach Erosion Board, Corps of Engineers: "Shore Protection Planning and Design," Tech. Report No. 4, Government Printing Office, Washington, D. C.
3. Beach Erosion Board, Corps of Engineers: "Waves in Inland Reservoirs," Tech. Memo, No. 132, Beach Erosion Board, Washington, D. C.
4. Gaillard, D. D.: "Wave Action," The Engineer School, Fort Belvoir, Va., 1935.
5. Franzius, Otto: "Waterway Engineering," The Technology Press, M.I.T., Cambridge, 1936.
6. Stevenson, Thos.: "The Construction of Harbors," Adam and Charles Black, Edinborough, 1886.
7. United Nations: "River Training and Bank Protection," Flood Control Series No. 4, Bangkok, 1953.
8. U. S. Weather Bureau: "Characteristics of the Hurricane Storm Surge," Tech. Paper No. 48, Government Printing Office, Washington, D. C.
9. Wessman, H. E. & Rose, W. A.: "Aerial Bombardment Protection," John Wiley & Sons, Inc., New York, 1942.

Report on Assignment 7

Relative Merits and Economics of Construction Materials Used in Waterfront Facilities

Shu-t'ien Li (chairman, subcommittee), B. M. Dornblatt, W. Binzen, W. H. Eschwig, J. H. Fitzpatrick.

Your committee reports progress in documenting information pertaining to the relative merits and economics of the following construction materials used in waterfront facilities:

(a) Prestressed concrete piles of square, hexagonal, octagonal, and circular cross sections.

(b) Prestressed cylindrical concrete piles, which are reported to have higher strength to resist direct and bending loads and to be less liable to cracking.

(c) Expansive-cement concrete for making reinforced or prestressed concrete piles, wharf decks, transit-shed roofs and wall panels.

(d) Side-by-side comparative performance records for untreated greenheart piles versus treated piles of southern pine and Douglas fir.

The following progress report on expansive cements and concretes is presented as information.

Expansive Cements and Concretes

By SHU-T'IEN LI

Chairman, Subcommittee 7, Committee 25—Waterways and Harbors;
Professor of Civil Engineering,
South Dakota School of Mines and Technology

Expansive cements and concretes, although they seem to be new artificial engineering materials, have had a long history of development. Efforts to evolve expansive cements have recurred during the past 74 years. However, success in producing such cements and applying them to controlled expansive concretes has been obtained only within the last 15 years.

The history of the development of expansive cements in France, the Soviet Union, and the United States is briefly reviewed in this report, and a bibliography on expansive cements and concretes is appended thereto. For salient properties of expansive mortars and concretes, readers are referred to appropriate original papers and articles cited in the bibliography. Data on both current and potential applications of expansive concretes may also be found therein.

Early Candlot's Salt and Michaelis Cement Bacillus

As early as 1890 it was established by Candlot that the interaction of tricalcium aluminate and calcium sulfate in an aqueous medium produced a hydrated salt of calcium sulfoaluminate. Long known as Candlot's salt, this product is now known as ettringite. When occurring between the tricalcium aluminate in portland cement and sulfates from aggressive waters, the reaction was attributed by Michaelis in 1892 as being responsible for the expansive disruption of otherwise sound concrete. Thereafter, he called Candlot's salt "cement bacillus."

Subsequent Basic Findings

Following the work of Candlot and Michaelis, chemists and engineers have diligently undertaken research to find ways of exploiting the considerable expansive forces set up during the formation of ettringite.

In 1929, W. Lerch, F W. Ashton, and R. H. Bogue reached the conclusion that there are, in reality, two sulfoaluminate hydrates of calcium: the low monosulfate of molecular composition $3CaO \cdot Al_2O_3 \cdot CaSO_4 \cdot 12H_2O$, and the high trisulfate of molecular composition $3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 30\text{–}32H_2O$. The high trisulfate forms and substantial expansion which, under restraint, exerts a large expansive force. The low sulfate, however, apparently does not expand on formation.

Later, in 1949, it was ascertained by F. Ferrari that a controlled formation of expansive sulfoaluminate will occur only in a medium supersaturated with respect to calcium ions and maintained at supersaturation during the formation period.

French Expansive Cements and Concretes

Early in the industrial development of expansive cement, the Lafarge Company found that the expansive reaction could be obtained by using a mixture of gypsum or plaster, aluminous cement, and portland cement, but the reaction was both erratic and difficult to control.

Subsequent major developments in expansive cement and concrete were made in the 1940's, principally by the French engineer, H. Lossier. His expansive cement, as indicated in an account published in 1949, consisted of a mixture, or blend, of portland cement and an expansive ground clinker claimed to be calcium sulfoaluminate. His method of control involved regulating the availability of water to the concrete and insuring termination of the reactions by introducing blast-furnace slag to the mixture. In 1952, Lafuma reported that the above-mentioned clinker consisted essentially of dicalcium silicate, calcium sulfate, and various calcium aluminates and ferrites.

However, rather little use has been made of this expansive cement, as the French engineers have experienced difficulty in controlling the expansion. Moreover, the magnitude of the self stressing was found generally not sufficient for prestressed concrete components of economical design.

In using the French expansive cement for making expansive concrete, conventional methods of mixing and placing were employed, but to terminate the expansion, besides introducing the slag terminator to the mixture, special methods of curing, including cessation of water curing, were necessary.

USSR Expansive Cements and Applications

The expansive cements being used in the Soviet Union consist of interground mixtures of portland cement, calcium-aluminate cement, and either gypsum or plaster of paris.

Since 1953 the use of expansive concrete for pressure pipes has been investigated intensively. The expansive mix consists of a mortar, having about 10 sacks of cementing material per cubic yard, placed by shotcrete methods, centrifugation, or vibro-squeezing equipment.

More recently, considerable research with self-stressing cement (SC), also of the above mixtures, has been undertaken by V. V. Mikhailov, as reported in 1957 and 1960. Hydrothermal methods of curing under close control are used to achieve the desired expansive self-stressing reactions.

Development of Expansive Cement and Concrete in the United States

The earliest major investigation in the field of expansive cement and concrete in the United States was the work of Alexander Klein and G. E. Troxell at the University of California (UC) at Berkeley. This research as reported in 1958 was directed toward the introduction of calcium alumino-sulfate clinkers and blast-furnace slag as admixtures to the concrete mix to produce expansion in plain concretes. At that time both the unrestrained and restrained mortar expansions were not yet satisfactory for the self prestressing of steel and concrete, but the important contribution of this research was in the definite proof of the stability of the system, $CaO \cdot Al_2O_3 \cdot SO_3$, and in determining the x-ray diffraction pattern of that system and of its several hydrates. The investigation thus provided important data on both the theoretical and applied chemistry of the expansive reaction, which aided in the subsequent successful development of expansive cements capable of producing expansive concretes for self prestressing of structural elements.

Further studies of improved expansive cements and concretes and their performance were conducted at the University of California from 1958 to 1961. Alexander Klein, Tsevi Karby, and Milos Polivka reported their results in the latter year.

The UC Expansive Cement

The expansive cement developed at the University of California consists of a blend of a portland cement component and a calcium-sulfoaluminate anhydrite component. The former is portland cement of a high tricalcium silicate and a low tricalcium aluminate content; the latter is made by grinding a clinker composed of calcium alumino-sulfate. The clinker has been proved by x-ray diffraction and petrographic examination to be, for the most part, a true anhydrous calcium sulfoaluminate, the remainder being free lime in an amount that may vary from 15 to 20 percent of the composition.

PCA Expansive Cements

The Portland Cement Association's expansive cements were made by mixing portland cement, calcium aluminate cement, and gypsum in varying proportions. In contrast to the USSR expansive cements, where the mixtures were produced by intergrinding, the PCA expansive cements were produced by simply blending commercial portland cement, calcium aluminate cement, and gypsum in a concrete mixer just prior to the addition of aggregate and water. The gypsum used was of reagent quality. Using differently blended mixtures by varying portland cement from 42 to 80 percent, calcium aluminate cement from 4 to 50 percent, and gypsum from 4 to 20 percent, PCA researchers investigated the effects of composition, and of time and cure temperature on mortar strength, free expansion, shrinkage, and development of stress in restrained specimens.

Potential Waterfront Applications of Expansive Concretes

Using predetermined proportions of expansive cement, proper curing methods and appropriate degrees of restraint, concretes can be designed to achieve such characteristic attributes as (1) Shrinkage compensation, (2) Crackproofness, (3) Waterproofness, (4) Wear resistance, and (5) Chemical prestressing—with no sacrifice in strength compared with conventional concretes. All these attributes arise from the controlled expansion made possible by the use of expansive cements.

Shrinkage compensation will reduce or even eliminate shrinkage stresses and shrinkage cracks. Hence, shrinkage-compensated concrete makes feasible the construction of lightweight roof slabs for transit sheds that are crackproof and require no waterproofing covering. Such concrete will reduce cracks in trucking pavements. It will help to render wharf decks crackproof and waterproof, and hence more wear-resistant, thus reducing deterioration. Shrinkage compensation is especially desirable in northern climates where pavements and decks are subject to freezing and thawing cycles, the adverse action of de-icing agents, and the abrasion of tire chains.

For partially submerged construction, prestressed concrete piles of square, hexagonal, octagonal, and round sections, and of cylindrical sections, have been used to good advantage because the prestressing tends to eliminate cracks and, hence, corrosion of the steel reinforcement. Where the water is brackish and salt-water spray is prevalent, prevention of cracks and reinforcement corrosion is especially important. Expansive-cement concrete should further enhance the resistance to sea water of both conventionally reinforced and prestressed concrete piles for waterfront applications.

Finally, chemical prestressing (also called integral prestressing, or self stressing, or prestressing by expansion) has been actually applied to pipes, and experimentally applied to hyperbolic paraboloid shells, etc. It promises further application to tanks, cylindrical piles, wall panels, other plate and shell constructions, etc., in waterfront installations.

BIBLIOGRAPHY ON EXPANSIVE CEMENTS AND CONCRETES

1890—1964

1. *Bulletin, de la Societe d'Encouragment pour L'industrie Nationale,* 1890, p. 682.
2. *Tonindustrie-Zeitung,* Vol. 16, 1892, p. 105.
3. Lerch, W.; Ashton, F. W.; and Bogue, R. H.—"The Sulfoaluminates of Calcium"; Paper No. 19, *Portland Cement Association Fellowship at the National Bureau of Standards,* Washington, D. C., April 1929.
4. Lossier, Henry and Caquot, A.: "Expanding Cements and Their Application—Self Stressed Concrete" (in French); *Le Genie Civil,* Vol. 121, 1944, No. 8, April 15, pp. 61–65; No. 9, May 1, pp. 69–71; Abstract in *Proc., ACI,* Vol. 41, 1945, pp. 238–240.
5. Lossier, H.: L'Autocontrainte des Betons par les Climente Expansifs"; *Memoires, Societe des Ingeniuers Civils de France* (Paris), No. 3–4, March–April 1949, pp. 189–225.
6. Ferrari, F.: "Cement with Controlled Expansion"; *Il Cemento* (Milan), No. 5–6, 1949, pp. 68–71.
7. Lossier, H.: "La Précontraint Integral Mixte ("The Self-Stressing of Concrete by Expanding Cements); *Le Genie Civil* (Paris), Vol. 127, December 1950, pp. 412–413.
8. Lossier, H.: "La Précontrainte Intégrale et les Ciments Expansifs" ("Integral Prestressing and the Expansive Cements"); *Precontrainte—Prestressing* (Brussels), Vol. 1, January–June, 1951, pp. 22–38.
9. Lafuma, H.: "Expansive Cements"; *Proc., Third International Symposium on the Chemistry of Cement* (London), 1952, pp. 587–597; Cement and Concrete Association, London.
10. Kammuller, K.: "Vorspannung durch Spreizen" (Prestressing by Expansion); *Der Baningenieur,* Vol. 28, April 1953, pp. 128–130.
11. Kühl, Hans von: "Quellzement" (in German, Expansive Cement); *Silikattechnik,* Vol. 6, No. 11, 1955, pp. 476–477.
12. Mikhailov, V. V.: "New Developments in Self-Stressed Concrete"; *Proc., World Conference on Prestressed Concrete* (San Francisco, Calif.), July 1957, pp. 25–1 to 25–12; University of California, Berkeley, Calif.

13. Klein, Alexander, and Troxell, G. E.: "Studies of Calcium Sulfoaluminate Admixtures for Expansive Cements"; *Proc. ASTM,* Vol. 58, 1958, pp. 986–1008.

14. Li, Shu-t'ien: "Prestressed Pavement Bibliography" (Containing related entries in expansive cement and concrete); *ACI Journal,* Vol. 31, No. 4, October 1959, (Proc., Vol. 56), pp. 341–348.

15. Mikhailov, V. V.: "Stressing Cement and the Mechanism of Self-Stressing Concrete Regulation"; *Proc., Fourth International Symposium on the Chemistry of Cement* (Washington, D. C.), Vol. II, 1960, Paper VIII–1, pp. 927–955.

16. Li, Shu-t'ien—"Bibliography on Airport Engineering" (A Compilation of Free World Literature Numbering 2,335 Entries Classified into 26 Groups and Arranged Chronologically, embracing related entries in expansive cement and concrete); *ASCE Publications* 41, X+170 pp., December 1960.

17. Klein, Alexander; Karby, Tsevi; and Polivka, Milos: "Properties of an Expansive Cement for Chemical Prestressing"; *Journal, ACI,* Vol. 58, No. 1, July 1961, Title No. 58–3, pp. 59–82; *Proc., ACI,* Vol. 58, 1961, Title No. 58–3, pp. 59–82.

18. Polivka, M. and Klein, A.: "Bond Strength Characteristics of Grouts Containing an Expansive Component"; *RILEM Bulletin,* The International Union of Testing and Research Laboratories for Materials and Structures, No. 13, December 1961, pp. 24–28.

19. Bertero, V.: "Chemically Prestressed Concrete Hyperbolic Paraboloid Shell"; *Proc., World Conference on Shell Structures* (San Francisco, Calif.), October 1962.

20. "Self-Stressing Concrete Tested"; *Engineering News-Record,* Vol. 170, No. 12, March 21, 1963, p. 171.

21. Chatterji, S. and Jeffrey, J. W.: "A New Hypothesis of Sulphate Expansion"; *Magazine of Concrete Research* (London), Vol. 15, No. 44, July 1963, pp. 83–86.

22. Lin, T. Y. and Klein, Alexander: "Chemical Prestressing of Concrete Elements Using Expanding Cements"; *Journal, ACI,* Vol. 60, No. 9, September 1963, Title No. 60–56, pp. 1187–1218; *Proc., ACI,* Vol. 60, 1963, Title No. 60–56, pp. 1187–1218.

23. Chatterji, S. and Jeffrey, J. W.: "A New Hypothesis of Sulphate Expansion"; *Magazine of Concrete Research* (London), Vol. 15, No. 44, July 1963, pp. 83–86.

24. Timms, Albert G.: "Self-Stressing Concrete" (Blakeslee puts in pilot installation); *Modern Concrete,* September 1963.

25. "Expansive Cement Prestresses Concrete"; *Engineering News-Record,* Vol. 171, No. 13, September 26, 1963, pp. 41–42.

26. Spellman, D. L.: "Living Pavements" (Division Experiments to Reduce Cracking); *California Highways and Public Works,* Vol. 42, No. 9–10, September–October 1963, pp. 51–54.

27. Whitcombe, David—"Special Report on Expansive Concrete"; *Flash Bulletin, Progressive Architecture,* November 1963.

28. Joseph, James: "Expansive Concrete"; *Progressive Architecture,* Vol. XLIV, No. 11, November 1963, pp. 178, 180, 182.

29. National Science Foundation—Annual Listing of Engineering Sciences Grants—Fiscal Year 1963, p. 2: University of California (Berkeley), P–11493, GP–616, Institute of Engineering Research, Bertero and Polivka, "A Basic Study of Expansive Cement and Expansive Concrete," 2 years, $114,900.

30. Li, Shu-t'ien: "Anti-deterioration, Wear-Resistant, and Crackproof Bridge Deck Wearing Course in Northern Climatic Environments"; Research in Progress—1964, Plain and Reinforced Concrete, Reported by ACI Committee 115—Research, *ACI Publication,* January 1964.

31. "Expanding Cement Prevents Roof Cracks"; *Engineering News-Record,* Vol. 172, No. 3, January 16, 1964, p. 32.
32. Concrete Research and Development Corporation—"Laboratory and Field Results of Compensated Shrinkage Cement Lightweight Concrete"; February 1964; Van Nuys, Calif.
33. Monfore, G. E.: "Properties of Expansive Cement Made with Portland Cement, Gypsum, and Calcium Aluminate Cement"; *Journal, PCA Research and Development Laboratories,* Vol. 6, No. 2, May 1964, pp. 2–9, PCA. R & D. Sec. 1047–2.
34. Bertero, V. V. and Polivka, P.: "Effect of Degree of Restraint on Mechanical Behavior of Expansive Concrete"; Paper presented to the June 1964 Annual Meeting of ASTM.
35. Li, Shu-t'ien: "An Outlook of Expansive Cements and Concretes"; *Concrete Construction* (Forthcoming).

Report of Committee 30—Impact and Bridge Stresses

J. W. Davidson,
Chairman

N. E. Ekrem,
Vice Chairman

E. S. Birkenwald
D. S. Bechly
J. A. Erskine
P. L. Montgomery
C. V. Lund
E. R. Andrlik
E. D. Ripple
L. N. Bigelow
E. R. Bretscher
K. L. DeBlois
W. E. Dowling
C. E. Ekberg, Jr.
D. J. Engle
R. J. Fisher
S. R. Gilbert
A. T. Granger
A. R. Harris
J. F. Hoss, Jr.
K. H. Lenzen
G. F. Leyh
J. F. Marsh
James Michalos
Za Lee Moh
W. H. Munse
D. W. Musser
C. H. Newlin
N. M. Newmark
M. Noyszewski
A. L. Piepmeier
M. J. Plumb
E. W. Prentiss
C. A. Roberts
M. B. Scott
C. B. Smith
Hernan Solarte
J. E. South
L. F. Spaine
F. W. Thompson
G. S. Vincent
C. T. Webster
J. R. Williams
E. N. Wilson
J. D. Woodward
L. T. Wyly

Committee

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 30.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

2. Steel truss spans.

   Old records of strain gage tests on a variety of truss spans are being reviewed, and a program of field tests is being developed to permit derivation of needed information on impact on truss spans produced by diesel locomotives and cars.

3. Viaduct columns, collaborating with Committee 15.

   Investigation of these members has generally been handled in conjunction with tests on other subjects. Due to lack of suitable tests, no progress has been made on this assignment in 1964.

4. Longitudinal forces in bridge structures, collaborating with committees 7, 8 and 15.

   Progress report, presented as information .... page 184

5. Distribution of live load in bridge floors, collaborating with Committee 15.

   The work on this assignment during the past year has dealt mainly with the preparation of design specifications for lateral and longitudinal distribution of loading in steel railway bridge floors. In this effort the committee has worked closely with Committee 15.

   In November 1960 a report of the University of Illinois on an investigation of the load distribution in steel railway bridges was presented to the subcommittee. This report served as a basis for suggested design recommendations that were submitted to Committee 30 by the subcommittee.

After detailed study and evaluation of the proposed design specification a revised recommendation was submitted to Committee 15, which is now in the process of reviewing these new requirements before submitting them for ballot. It can be expected that revised design specifications for the lateral and longitudinal distribution of loading in steel railway bridge floors will soon be in effect.

6. Concrete structures, collaborating with Committee 8.
   Progress report, presented as information .... page 185

7. Timber structures, collaborating with Committee 7.
   A test program to determine stresses in various types of wood trestles, and in glued laminated wood girders, has been laid out, but progress has been hampered by lack of research funds.

8. Vibrational characteristics of bridges affecting deflections and depth ratios.
   A method of investigating this problem by using an electronic computer has been developed by New York University. However, this investigation has been dormant during the past year due to lack of research funds. A program of field tests of shallow spans, incorporating simulated excessive span deflections, is being prepared with the object of investigating whether existing span depth ratio limitations can be liberalized.

9. Use of electronic computers for railroad bridge programs, collaborating with Committee 15.
   Ten moment and shear tables for special heavy railroad cars have been prepared for addition to the tables which were distributed to chief engineers of Member Roads in 1960 and 1961. The AAR Moving Load Program for the IBM 650 computer has been rewritten in Fortran to make it more readily adaptable to various types of computers.

10. Steel continuous structures, collaborating with Committee 15.
    A program of field tests of additional continuous bridge spans has been laid out, but actual testing has not progressed due to lack of funds.

11. Composite design of steel structures having concrete deck, collaborating with Committees 8 and 15.
    Due to lack of research funds, progress in this assignment has been limited to a review of work in this field being carried out by others.

THE COMMITTEE ON IMPACT AND BRIDGE STRESSES,
J. W. DAVIDSON, *Chairman.*

AREA Bulletin 588, November 1964.

Report on Assignment 4

Longitudinal Forces in Bridge Structures

J. A. Erskine (chairman, subcommittee), S. R. Gilbert, J. F. Hoss, G. F. Leyh, C. V. Lund, J. F. Marsh, A. L. Piepmeier, C. A. Roberts, H. Solarte, L. F. Spaine, L. T. Wyly.

A report on field tests on two concrete bridges on the Seaboard Air Line Railroad near Clinton, S. C., was prepared by the AAR Research staff and reviewed by Committee 30. For one of these bridges—a prestressed concrete pile trestle—the tests included measurements of stresses in the piling and in the running rails resulting from longitudinal forces produced by traction and braking of the test train. These data have been published in Report No. ER–48.

In April 1964 the research staff conducted tests on a prestressed concrete trestle on the Western Pacific Railroad near Stockton, Calif., which included measurement of bending stresses in the piling resulting from longitudinal forces.

Tests were made late in 1964 on a 660-ft prestressed concrete trestle on the Santa Fe Railway at Dallas, Tex., which included a comprehensive series of measurements of the longitudinal forces produced, and their effects on the bridge and track structure. A report will be prepared after strain gage readings and other data are analyzed.

Report on Assignment 6

Concrete Structures

Collaborating with Committee 8

P. L. Montgomery (chairman, subcommittee), J. W. Davidson, C. E. Ekberg, Jr., N. E. Ekrem, J. A. Erskine, J. F. Hoss, Jr., W. E. Dowling, K. H. Lenzen, G. F. Leyh, C. V. Lund, Z. L. Moh, J. Michalos, N. M. Newmark, M. Noyszewski, A. L. Piepmeier, E. D. Ripple, F. W. Thompson, C. T. Webster, J. R. Williams, J. D. Woodward.

This year's activity was culminated by the publication of Report No. ER–48 covering results of field tests conducted by the AAR research staff on two Seaboard Air Line concrete slab bridges. The tests provided an opportunity to compare a 7-span, 134-ft-long, conventionally reinforced bridge with a 6-span, 148-ft-long prestressed structure. Information was also obtained on the loading effects to concrete piling.

The behavior of both bridges conformed to results of previous tests. It was of particular interest to find that (1) stresses were less than calculated, (2) transverse load distribution was nearly uniform across the decks, (3) impact increased slightly with speed for the conventionally reinforced spans, but remained nearly constant for the prestressed span, (4) recorded impacts were considerably less in the prestressed span, (5) maximum impacts occurred under the locomotive, but maximum live-load-plus-impact stresses occurred under the cars, (6) wheel irregularities caused high impacts of short duration, and (7) a rail joint influenced total impact values on one span.

ROOTS AND LOADS TIES

LAYING WELDED RAIL

9' WIDE TRACK CLEANING BUCKET

SPEED SWING

MODEL 441

Developed and Built
for Railroad Maintenance

180° BOOM SWING

DOES ALL JOBS!

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
- Back Filler Blade
- Pull Drag Bucket
- 4 Cu. Yd. Snow Bucket
- Pile Hammer

Optional Attachment
Flanged Wheels, Hydraulically Controlled

PETTIBONE MULLIKEN CORPORATION

RAILROAD PMCO DIVISION
141 W. JACKSON CHICAGO 4, ILL.

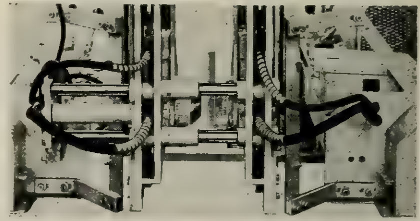
80 Years of Service
to the Railroad Industry

is saving thousands of man-hours tightening rail anchors with a RACINE

Loose rail anchors are as useless as weeds in the right-of-way. But an AnchorTight attachment on your Racine Anchor-Fast machine can reset old loose and misapplied anchors 100% tight to ties in seconds.

Four powerful, hydraulically-operated arms "squeeze" boxed anchors of any type with up to 50,000 lbs. pressure. The AnchorTight attachment easily replaces regular anchor applicator assembly; is raised and lowered hydraulically. Guide bars accurately position wearplates for fast operation. Adjusts to fit any rail from 90 to 155 lbs.

Write for details on the improved Racine Anchor-Fast applicator and AnchorTight attachment.



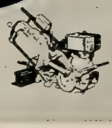
APPLIES UP TO 22 ANCHORS PER MINUTE. This new nipper assembly, with positive-alignment side guide-brackets, is one reason the Anchor-Fast is now more efficient than ever. Other improvements include a 300% increase in boxing pressure; elimination of 115 parts to simplify maintenance. Modernizing kits available for your present Anchor-Fast machines. RR-195

RACINE

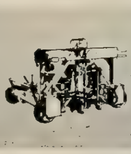
RACINE HYDRAULICS & MACHINERY, INC.
Dept. F-94, Racine, Wisconsin

Unit Tamper

Portable Rail Drill

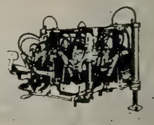


Portable Rail Saw

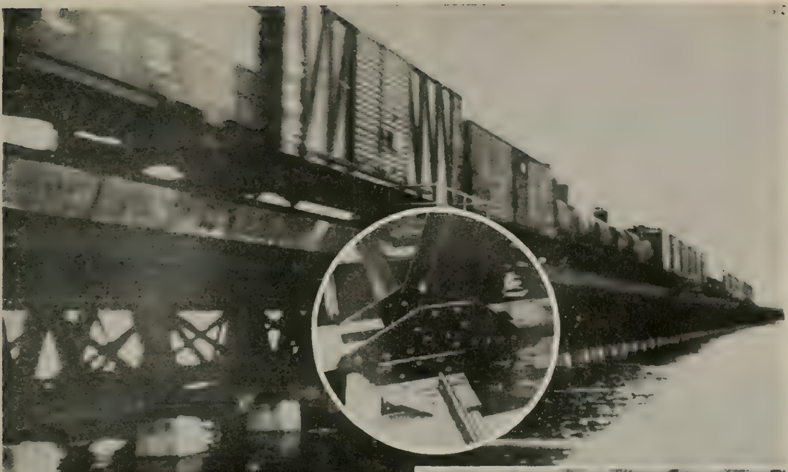


Anchor Applicator

Rail Drill&Saw



Production and Spot Tampers



The railroad bridge pictured has been protected satisfactorily with Brooks Protective Coating for over five years. The steel in the structure is subjected to atmospheric contamination, water action and winter snow and ice.

BROOKS

PROTECTIVE COATING FOR BRIDGES AND BUILDINGS

Corrugated metal buildings are subjected to corrosion and in some cases, severe corrosive conditions exist. Brooks Protective Coating will resist corrosion which causes deterioration to metal surfaces.

Easily applied by spray or brush.

Talk it over with the BROOKS OIL man near you!

The BROOKS OIL Company

Established 1876

General offices and U.S. plant: 3304 East 87th Street • Cleveland 27, Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton, Ontario

The Brooks Oil International Company: Exporters

Extend Tie Life!

Hold Gage!

USE TIE PLATE *LOCK SPIKES*

One-piece Design

LOCK SPIKES hold tie plates firmly in place on cross-ties and bridge timbers.

LOCK SPIKES are quickly and easily driven, or removed, *with standard track tools.*

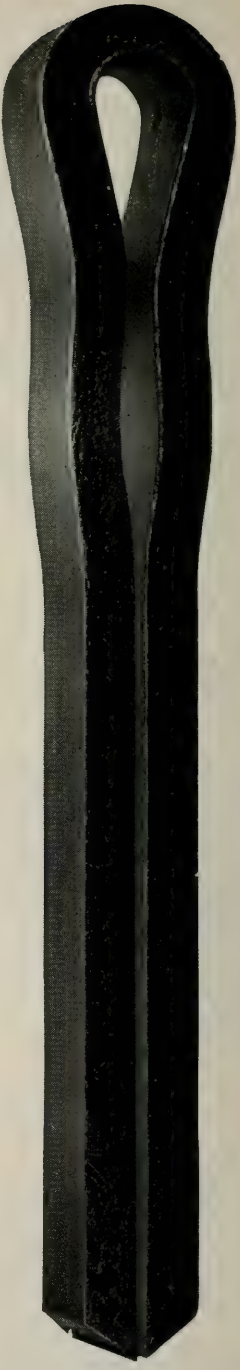
Driven to refusal, the spread shank is compressed by the walls of the hole. Tie plates are held against horizontal and vertical movement under spring pressure. Play between the spike and the hole is eliminated—abrasion and seating of tie plates is overcome.

LOCK SPIKES hold their position in the tie, and redriving to tighten the plate is not required. They provide a quiet and strengthened track.

Annual cost of ties and maintenance expense is reduced by extending the life of ties and holding gage. Here is one answer to conservation of materials and labor. Write for free folder.

BERNUTH, LEMBCKE CO., INC.

420 Lexington Avenue, New York 17, N. Y.

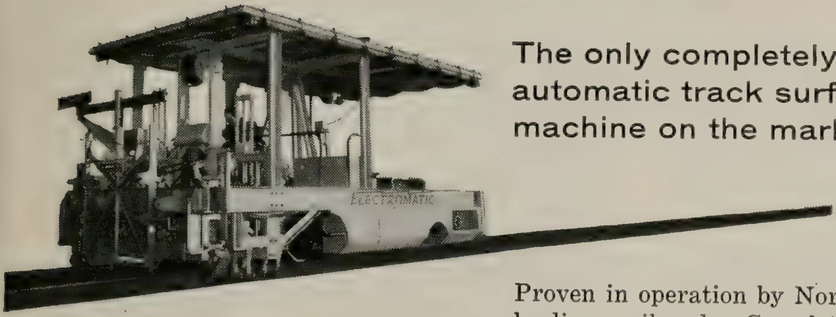


Actual Size

Tamper

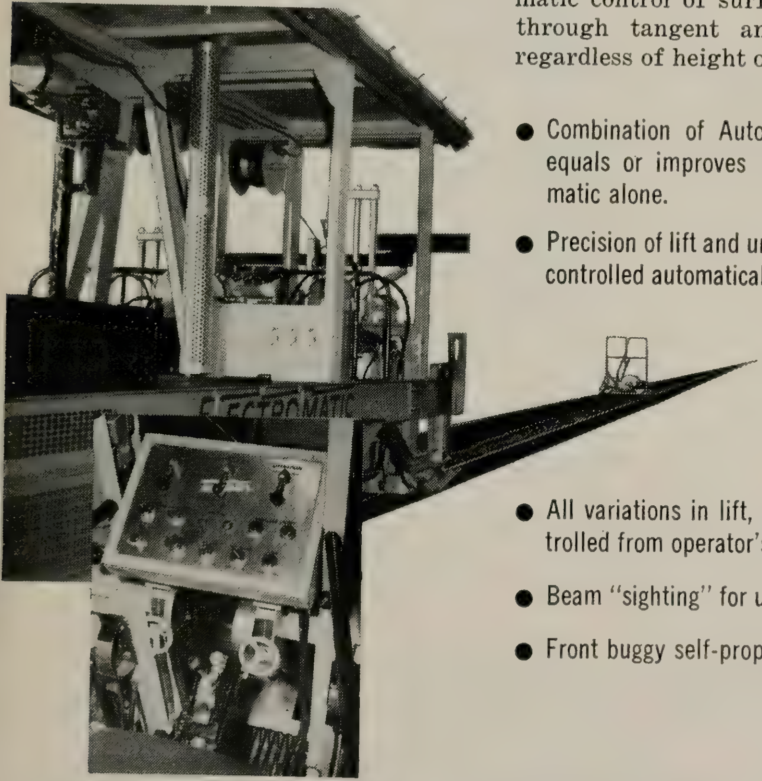
AUTOJACK ELECTROMATIC

The only completely automatic track surfacing machine on the market



Proven in operation by North America's leading railroads. Complete and automatic control of surface and cross level through tangent and curve territory regardless of height of lift.

- Combination of Autojack and Electromatic equals or improves production of Electromatic alone.
- Precision of lift and uniformity of compaction controlled automatically.



- All variations in lift, level and run-out controlled from operator's panel.
- Beam "sighting" for utmost precision.
- Front buggy self-propelled ahead of tamper.

Tamper

TAMPER INC. 53 Court St., Plattsburgh, N.Y.

SALES AND SERVICE: 2147 University Avenue
St. Paul 14, Minnesota
Phone: 645-5055

IN CANADA 160 St. Joseph Blvd.,
Lachine (Montreal), P.Q.
Phone: 637-5531

Your enquiries for detailed information or brochures on Autojack Electromatic and other track machines are invited.

WOODINGS-VERONA TOOL WORKS

Pioneer Manufacturers

of

HIGH GRADE TRACK TOOLS

and

SPRING WASHERS FOR TRACK

Since 1873

VERONA, PA. CHICAGO, ILL.

WOODINGS FORGE & TOOL COMPANY

Makers

of

WOODINGS RAIL ANCHORS

VERONA, PA. CHICAGO, ILL.

Notes on

Railroad Location and Construction Procedures

from the School of Experience

By J. A. Given

A series of notes, comments, short-cut methods and "tricks of the trade" written by a railroad location engineer of many years of practical experience for the benefit of young engineers.

Price $0.50

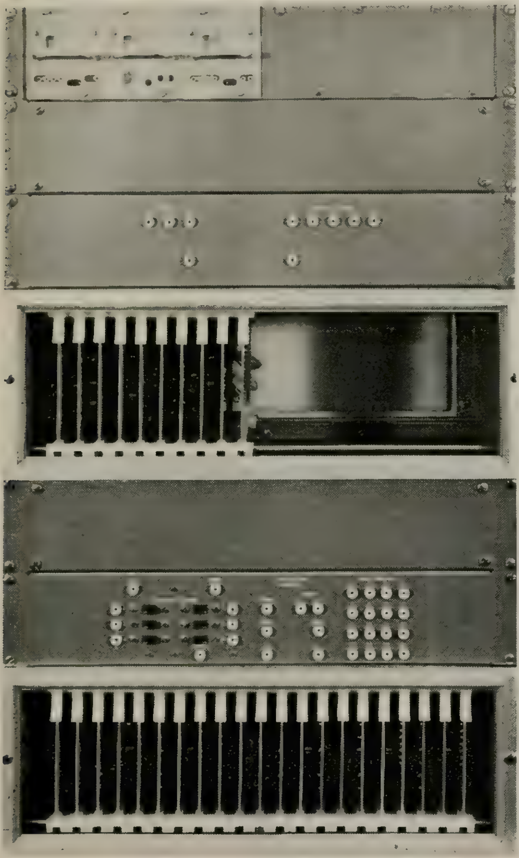
AMERICAN RAILWAY ENGINEERING ASSOCIATION

59 East Van Buren Street

Chicago 5, Ill.

FAST, ELECTRONIC CONTROL SYSTEM

SOLID STATE FOR



Quick-detachable, solid-state modules are enclosed in dust-tight cabinets.

- ★ ***SPEED***
- ★ ***FLEXIBILITY***
- ★ ***EASY MAINTENANCE***

Now GRS offers you another practical application of solid state techniques to cTc and remote control—the GRS Type L coding system.

It's *flexible.* You install equipment to meet present needs only. Future expansion is simplified with Type L's modular, printed circuit design. Operation is duplex—controls go out and field data feeds in, simultaneously. Information on field conditions is always current.

It's *easy to maintain* because Type L's solid-state components and heavy-duty printed circuit boards are virtually trouble free. Test points are right out in front, enable complete system checks without interrupting normal operation.

REMEMBER PLEASE: When you specify GRS, you can get all your signaling from one source—not only the electronic control system, but also the signals, switch machines, control console, etc.—everything you need, including experienced railway signaling systems engineering.

3311

GENERAL RAILWAY SIGNAL COMPANY

A UNIT OF GENERAL SIGNAL CORPORATION **ROCHESTER, N.Y. 14602**

NEW YORK, N.Y. 10017 CHICAGO, ILL. 60601 ST. LOUIS, MO. 63101 MONTREAL 2, P. Q.

Hubbard Super Service Alloy Spring Washers

Hubbard Super Steel Alloy Spring Washers

Hubbard Track Tools

Hubbard Tool Division

UNIT RAIL ANCHOR CORPORATION

New York Pittsburgh Chicago

Unit Rail Anchor

UNIT RAIL ANCHOR DIVISION

UNIT RAIL ANCHOR CORPORATION

NEW YORK PITTSBURGH CHICAGO

P. O. Box 10378

Area Code 305
LOgan 6–7922

GREENHEART, INC.

1431 N. E. 26th Street
FORT LAUDERDALE, FLORIDA

President—John L. McEwen—Quarter Century Experience

IMPORTERS:

GREENHEART—3300F Piles, Lumber, Timbers Long Length

MORA EXCELSA—Lumber and Timbers

MANBARKLAK—Piles

ANGELIQUE (Basra Locus)—Piles, Lumber and Timbers
and other Woods from

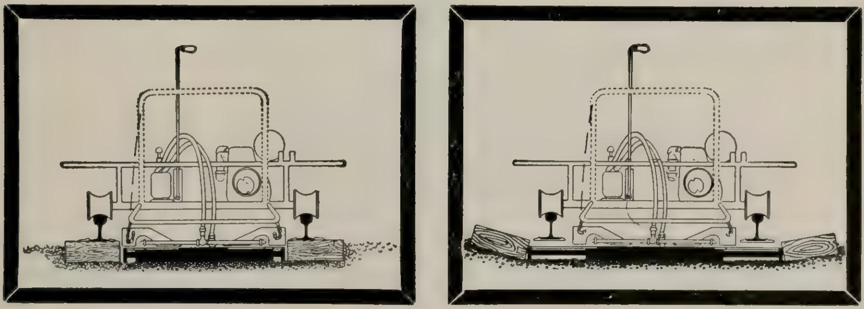
Burma, Siam, Australia, Africa and South America

Data furnished on request

Model N U Tie Cutter

HERE IS THE WINNING TEAM

The Woolery NU Tie Cutter and the Woolery Tie-end Remover preserve the line and surface of the track and at the same time reduce the cost of tie renewals. Ties can be removed without trenching, jacking up track or adzing tops of rail-cut ties. With this team you simply cut both ends of tie, pry out center piece, insert in its place the tie-end remover and out go the tie ends pushed by the double acting, double ended hydraulic cylinder of the Tie-end remover.



FOR HIGHEST EFFICIENCY USE TWO TIE CUTTERS WITH ONE TIE-END REMOVER

WOOLERY MACHINE COMPANY

MINNEAPOLIS, MINN.

Assure lower maintenance costs,
better performance with...

TEXACO

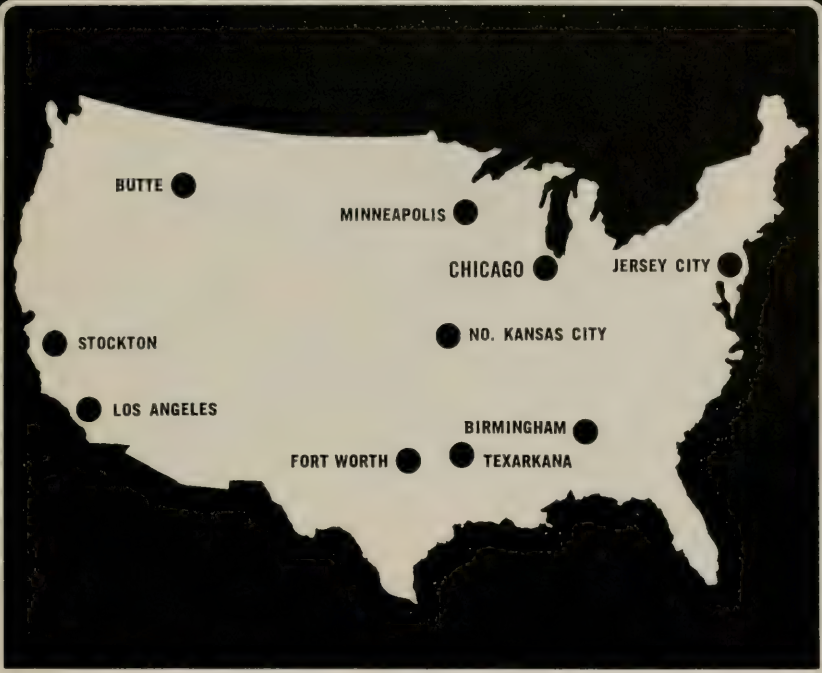
Petroleum Products and Systematic Engineering Service

TEXACO INC.
RAILWAY SALES DIVISION
135 East 42nd St., New York 17, N. Y.

NEW YORK • CHICAGO • SAN FRANCISCO • ST. LOUIS • ST. PAUL • ATLANTA

THE DOUBLE U RAIL ANCHOR

ACHUFF RAILWAY SUPPLY CO.
ST. LOUIS, MO.



U.S. BORAX OFFERS COMPLETE VEGETATION CONTROL SERVICE AND PRODUCTS THROUGHOUT THE COUNTRY

Our railroad herbicide specialists know your regional weed, soil, and weather conditions. They have an extremely wide selection of weed and brush killing chemicals. Now, with strategically located production facilities and the most efficient spray cars in railroading today, U.S. Borax is fully equipped to contract for any vegetation control program—and carry it out promptly, effectively and economically.

We would like an opportunity to prove it to you. Write today.

3456 Peterson Avenue, Chicago 45 • INdependence 3-6262

U.S. BORAX

IMPROVED HIPOWER

A COMPLETE LINE OF SPRING WASHERS

THE NATIONAL LOCK WASHER CO.
Newark N. J., U. S. A.

P. & M. PRODUCTS
- IMPROVED FAIR Rail Anchors

RAIL JOINT PRODUCTS
- Rajo Joints
- Insulated Joints
- Compromise Joints
- Fibre

MAINTENANCE EQUIPMENT PRODUCTS
- Meco Rail and Flange Lubricators
- Meco Rail Layers
- Meco Brush Cutters
- MACK Reversible Switch Point Protectors

PEERLESS EQUIPMENT PRODUCTS
- Draft Gears
- Rail Titan Batteries

IN CANADA:
The P. & M. Company Ltd..

552AB

PRODUCTS OF PROGRESS

POOR & COMPANY
Railway Products Division 80 E. Jackson Blvd., Chicago 4, Ill.

Stop weeds up to 18 months with just one application of UROX® Weed Killer!

Now you can stop weeds on your tracks for as long as 18 months with one application of Urox—Allied Chemical's powerful new weed killer. Urox is economical. Its effects are cumulative, so small "booster" doses keep its killing power going year after year. For really *complete* weed control, get Urox now! Available in both liquid and granular forms . . . special grades for special problems. Write for more information.

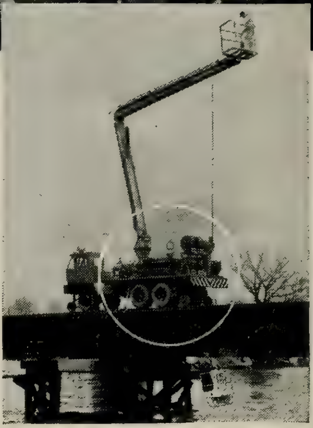
Allied Chemical

GENERAL CHEMICAL DIVISION
P. O. Box 353, Morristown, N. J.

Get any coating job done... ANYWHERE with

GRACO

HYDRA-SPRAY



The custom-built assembly shown above and to the right is an all-purpose rig designed to give *maximum* flexibility in coating and painting work. It was designed for field application of paints, lacquers, vinyls, cutback asphalts, creosotes, heavy oils and greases.

It uses the *economical* Graco Hydra-Spray Process, and proves once again, you get the job done faster and better with Graco than with any other coating system.

If speed of coating application, and material savings are important to you, write today for all the details of the Graco Hydra-Spray Process.

FREE! Graco Engineers are prepared to help you in the design of your paint and material spray assemblies. Your Graco Railway Representative will be glad to explain the many benefits of this service. Write or call him . . . *today!*

GRACO **RAILWAY DEPARTMENT**

GRAY COMPANY, INC.
MINNEAPOLIS 13, MINNESOTA

JOHN P. McADAMS, Eastern Sales Representative
2304 Wilson Boulevard, Arlington, Virginia

CHICAGO—(Broadview, Ill.)
R. D. Worley
3030 South 25th Ave.

CLEVELAND
M. H. Frank Company, Inc.
1202 Marshall Building

HOUSTON
Houston Railroad Supply Co.
1610 Dumble Street

PHILADELPHIA
The A. R. Kidd Co.
1036 Suburban Station Bldg.

LOUISVILLE
T. F. & H. H. Going
6308 Limewood Circle

ST. LOUIS
The Carriers Supply Company
818 Olive Street

NEW YORK—Newark, New Jersey
R. A. Corley
744 Broad Street

SAN FRANCISCO
The Barnes Supply Company
141 Eleventh Street

TWIN CITIES—St. Paul, Minn.
The Daniel L. O'Brien Supply Company
Endicott-On-Fourth Bldg.

WASHINGTON—Arlington, Va.
Southeastern Railway Supply, Inc.
2304 Wilson Blvd.

MONTREAL—Ontario, Canada
International Equipment Co., Ltd.
360 St. James Street West

PROGRESS REPORT

SPENO

Here are the up-to-date facts on the SPENO Ballast Cleaning and the SPENO Rail Grinding Services.

BALLAST CLEANING

SPENO Engineering and Research has developed a superior screening arrangement so that we are now using an improved Ballast Cleaner with greater efficiency.

RAIL GRINDING

Our Rail Grinding Service has been so well received — we now have *Three* Rail Grinding Trains to take care of the demand.

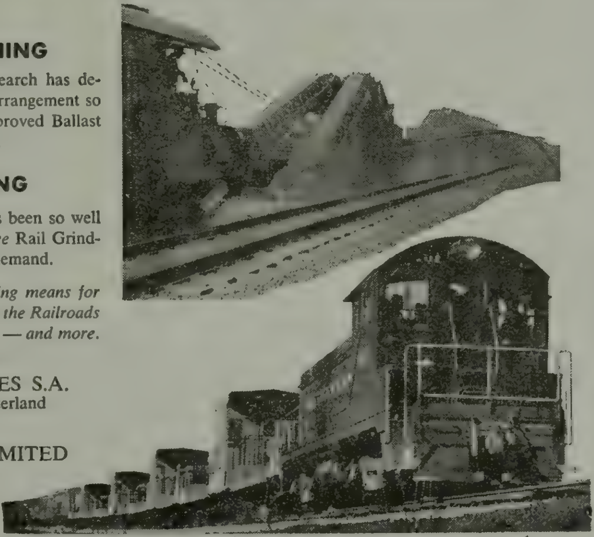
SPENO is constantly developing means for better service to make sure that the Railroads receive everything they pay for — and more.

Outside North American continent:

SPEMA RAIL SERVICES S.A.
Grand-Pont 2, Lausanne, Switzerland

Canadian Sales Representatives:

THE HOLDEN CO. LIMITED
614 St. James St., West
Montreal, Canada

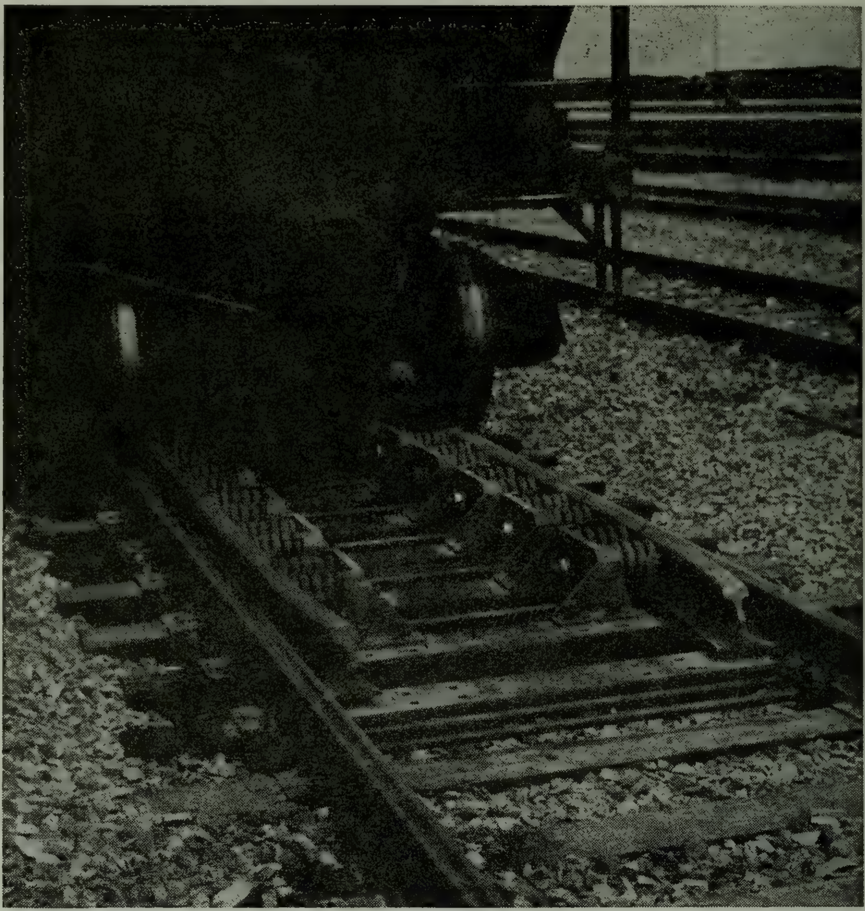


Just Ask the Railroads That have used us!

FRANK SPENO RAILROAD BALLAST CLEANING CO., INC.

Clark Street
East Syracuse, N. Y.

306 North Cayuga St.
Ithaca, N. Y.



THE TRASCO CAR RETARDER

HUNDREDS IN SERVICE
IN CLASS YARD TRACK

TRACK SPECIALTIES COMPANY
P.O. BOX 729 WESTPORT, CONNECTICUT

American Railway Engineering Association—Bulletin

Bulletin 589
Proceedings Vol. 66*

December 1964

REPORTS OF COMMITTEES

6—Buildings 187
3—Ties and Wood Preservation 225
11—Engineering and Valuation Records 231
28—Clearances 245
22—Economics of Railway Labor 257
27—Maintenance of Way Work Equipment 273

The reports in this issue of the Bulletin will be presented to the 1965 Annual Meeting of the Association at McCormick Place, Chicago, March 23–25. Comments and discussion with respect to any of the reports are solicited, and should be addressed to the chairman of the committee involved, in writing in advance of the Meeting, or from the floor during the Meeting.

---

* The contents of this Bulletin and the other Bulletins of the Association from Bulletin 587, September–October 1964, to and including Bulletin 593, June–July 1965 (except Bulletin 592, March 1965), will constitute the Annual Proceedings of the Association, Vol. 66.

Copyright 1964, by American Railway Engineering Association

BOARD OF DIRECTION

1964–1965

President

T. F. Burris, Special Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

Vice Presidents

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.

J. M. Trissal, Vice President, Illinois Central Railroad, Chicago, Ill. 60605

Past Presidents

C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania Railroad, Philadelphia, Pa. 19104

L. A. Loggins, Chief Engineer, Southern Pacific Company, Texas and Louisiana Lines, Houston, Tex. 77001

Directors

W. L. Young, Resident Vice President, Norfolk & Western Railway, Roanoke, Va.

T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va. 23213

C. E. Defendorf, Chief Engineer, New York Central System, New York, N. Y. 10017

John Ayer, Jr., Vice President—Operations, Denver & Rio Grande Western Railroad, Denver, Colo. 80217

A. L. Sams, Chief Engineer, Illinois Central Railroad, Chicago, Ill. 60605

D. C. Hastings, Assistant Vice President—Operations, Atlantic Coast Line Railroad, Jacksonville, Fla. 32202

B. B. Lewis, Professor of Railway Engineering, Purdue University, Lafayette, Ind.

H. M. Williamson, Chief Engineer System, Southern Pacific Company, San Francisco, Calif. 94105

H. E. Wilson, Assistant Chief Engineer—System, Atchison, Topeka & Santa Fe Railway, Chicago, Ill. 60604

J. S. Parsons, Erie–Lackawanna Railroad, Cleveland, Ohio. 44115

S. H. Poore, Office Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

F. N. Beighley, Roadway Engineer, St. Louis–San Francisco Railway, Springfield, Mo. 65801

Treasurer

A. B. Hillman, Retired Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago.

Executive Secretary

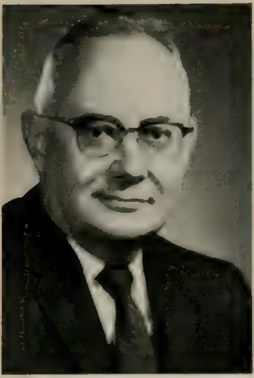
Earl W. Hodgkins, 59 East Van Buren Street, Chicago, Ill. 60605

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Street, Chicago, Ill. 60605

Published by the American Railway Engineering Association, Monthly, January, February, March,
November and December; Bi-Monthly, June-July, and September-October, at 2211 Fordem
Avenue, Madison, Wis.; Editorial and Executive Offices,
59 Van Buren Street, Chicago 5, Ill.
Second class postage paid at Madison, Wis.
Accepted for mailing at special rate of postage for in Section 1103, Act of October 3, 1917,
authorized on June 29, 1918.
Subscription $10 per annum.

Report of Committee 6—Buildings



J. W. Hayes, *Chairman*

W. C. Humphreys,
Vice Chairman

O. C. Denz, *Secretary*

W. G. Harding
C. R. Madeley
H. A. Shannon, Jr.
A. F. Langmeyer
W. R. Hyma
H. R. Helker
R. J. Martens
D. A. Bessey
I. G. Forbes
J. H. Adams, Jr.
J. L. Agee
W. F. Armstrong
F. R. Bartlett
S. M. Bielski
G. J. Bleul
E. P. Bohn
W. L. Burgess
R. R. Cahal
A. C. Cayou
R. L. Charlow
A. W. Charvat
H. M. Church (E)
J. S. Cooper
F. D. Day
A. G. Dorland (E)
V. E. Elshoff
C. S. Graves
A. R. Gualtieri
J. W. Gwyn
A. T. Hawk (E)
K. E. Hornung
E. J. Hynes
H. J. Lieser
R. E. Lilliston
D. F. Logan
W. H. McCauley, Jr.
W. K. McFarling
G. H. McMillan
G. A. Morison
L. S. Newman
L. J. Nichols
W. C. Panarese
C. L. Robinson
J. T. Rowan
J. B. Schaub (E)
T. H. Seep
Loren Shedd
E. R. Shultz
L. D. Smith, Jr.
R. C. Smith
M. L. Thornbrough, Jr.
R. C. Turnbell
R. A. Ullery
S. G. Urban
O. G. Wilbur (E)
T. S. Williams
Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 6.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, with recommendations submitted for adoption .... page 188
2. Specifications for railway buildings.
   Progress report, submitted as information .... page 191
3. Use of synthetic resins for adhesives in connection with railway buildings.
   Final report, presented as information .... page 195
4. New advances in paint and coating products for railway buildings.
   Final report, presented as information .... page 199
5. Prestressed concrete for railway buildings, collaborating with Committee 8.
   Final report, presented as information .... page 202
6. Use of plastic materials in railway buildings.
   Final report, presented as information .... page 210
7. Curtain wall construction for railway buildings.
   Study in progress, but no report.

8. Infra-red ray heating, collaborating with Committee 18.
   Final report, presented as information .... page 222

9. "Critical Path Method" for architects and engineers in the railway building field.

   Special feature on this subject to be presented at the Annual Meeting in March 1965.

THE COMMITTEE ON BUILDINGS,
J. W. HAYES, *Chairman.*

AREA Bulletin 589, December 1964.

Report on Assignment 1

Revision of Manual

W. G. Harding (chairman, subcommittee), J. H. Adams, Jr., F. R. Bartlett, S. M. Bielski, R. L. Charlow, O. C. Denz, C. S. Graves, G. A. Morison, L. S. Newman, L. J. Nichols, Loren Shedd, E. R. Shultz, R. C. Turnbell.

Your committee submits for adoption the following recommendations with respect to Chapter 6 of the Manual:

Delete in its entirety the material under Passenger Stations, pages 6–20–1 to 6–20–4, incl., substituting therefor the following:

PASSENGER STATIONS

The functional requirements for modern railroad passenger stations have become so varied and complex that it is virtually impossible to apply any standard yardstick to the design of this type of facility. Station structures may vary in size from an unattended wayside or suburban shelter to a large metropolitan terminal or a through station. The requirements to be satisfied will range from simple weather protection to housing a huge complex encompassing the many functions required for the operation of a railroad, plus a variety of associated and supporting commercial activities.

Certain generally accepted design principles may be employed as guide lines, however, in the design and preparation of plans for a passenger station, and these principles are correlated in this material.

Because of constantly increasing terminal costs and the steadily rising spiral of labor and service charges, it is imperative, in planning passenger station facilities, that prime consideration be given to economics, operating efficiencies, and reduced operating costs. These important considerations should be an integral part of the basic design program, and a thorough and complete analysis should be made of them.

Probably the most conventional solution to the problem of satisfying economic considerations is consolidating and combining operations wherever possible. This may take the form of a consolidated freight and passenger facility, or mail facility, where supervisory, clerical and service personnel can serve in multiple capacities. Complete operating and work-flow studies should be made to determine if additional savings can be realized by consolidating the work of other associated operating, sales and supervisory personnel into this type of facility.

Urban redevelopment programs in many cities are causing rapid inflation in land and property values, and many railroads find themselves with valuable station properties in what were once low-value slum areas. These programs in many cases afford railroads an opportunity to re-examine their station-facility requirements. Economics may dictate that the railroads should sell their station properties and relocate and consolidate the facilities in a more suitable location. An alternate solution is selling existing station properties for commercial development and then leasing space for passenger facilities in the commercial buildings constructed on the sites.

Still another economic consideration to be investigated is the possibility of relocating passenger terminals to areas contiguous to freight terminals so that freight yard crews can handle the passenger station switching and freight carmen and yardmen can handle the passenger station servicing.

The importance of developing an intelligent, adequate and comprehensive basic design program cannot be overstressed. In order that no facet of this phase will be overlooked, the appropriate operating officers and the officers of all associated and related departments should be consulted.

With a good basic design program to work from, the detail planning will resolve into a purely architectural development. The design program and the architectural development are of equal importance, but the design program generally requires management policy decisions which must be reached before the architectural solution can be developed.

From the basic design requirements there should come the complete information on which to base the architectural plans. This information should include the extent and type of operations to be incorporated, the number of people to be accommodated, the various services that will be required, and the economic justification. One of the most important factors in the economic justification should be the construction budget estimate. With this as the controlling factor and the functional requirements as a guide, the development of plans should then become academic.

As in the development of the basic design program, economics should be a prime consideration in the development of the architectural plans. This is not to say that aesthetics should be overlooked. It is only by first satisfying the functional and economic requirements, however, that an acceptable architectural solution can be achieved. It is true architecture then which adds aesthetic satisfaction to the first two requirements.

In the selection of construction materials, thought should be given to utilizing some of the many elements of prefabricated and pre-engineered building components that are available. The use of these materials can greatly reduce the cost of field labor. They range from precast concrete units and the various types of panel roof-deck units, through the broad range of steel-joist, beam, and post framing units, to completely prefabricated building units. These include panel walls, panel door assemblies, panel partitions, and even panel heating assemblies. By thoughtful use of these standard units, buildings can be designed that are pleasing in appearance though inexpensive in cost.

The general layout and traffic-flow arrangement should be designed to permit the most efficient and expeditious handling of passengers while at the same time giving consideration to their convenience, comfort, and safety.

There are at least two schools of thought relative to the best pattern of traffic flow in a passenger station. This matter should be resolved in the basic design program, and concession, sales, and operating departments should concur in the proper approach.

One school of thought stresses the concept of establishing the traffic pattern in such a way that passengers may unload from cars or cabs, enter directly into a service concourse which contains the ticket sales and baggage-checking counters, public toilets, telephones, baggage-checking lockers and other service areas, conduct their transactions and proceed directly to the station platforms to await incoming trains. The waiting room, restaurant and concession spaces then become accessory lounge areas for those who desire to use them, and are not used as main circulation areas. There are many variations in this pattern, but in all of them the idea is to move traffic through the station quickly and efficiently.

The opinion of the other school of thought, and it has economic justification, is that the traffic should be routed through and past the concession areas so that the greatest advantage can be taken of impulse buying. The ticket selling and service areas then become the accessories. The waiting room may be part of the concession area or also an accessory. The size of the station and the concession demand will play the major parts in reaching a decision on a layout and traffic pattern of this kind.

The determination of space allocation for the various uses is very much a matter of occupancy demand and equipment space requirements.

Passenger station waiting rooms should be designed for maximum normal occupancy, not for peak occupancy. This is particularly true at locations which have unusually high seasonal peak loads. It may be desirable to furnish ticket sales and baggage checking facilities to accommodate these peak loads, however.

Once the maximum normal occupancy has been determined, the area of the waiting room can be calculated by applying the generally accepted rule-of-thumb design factor of 13 sq ft of floor area per person. Experience has shown that this factor should be modified, depending upon the number of people to be accommodated, between a range of 10 and 15 sq ft per person. Smaller occupancies will require 15 sq ft per person. Larger occupancies will only require 10 sq ft per person. This results from more effective use of circulation space in larger facilities.

While the rule-of-thumb factor has proven to be a dependable method of calculating waiting-room areas, local building codes should always be checked to see if there are any conflicting requirements.

In making a determination of the public toilet-room requirements, the local building-code area, ventilation and fixture unit requirements should be adhered to.

The determination of requirements for news-stand and food-dispensing concesssions should be made jointly by local operating people and the concession operators. Of interest to both parties is the need to provide facilities adequate to meet the demand, and of a size that can operate efficiently and produce a profitable return to both the concessionaire and the owner.

The requirements for other passenger-service accommodations, such as parcel checking lockers, public telephones, automobile rental stations, Travelers Aid stations, Western Union service, cab stand, etc., are also usually developed jointly by the local operating people who are familiar with the demand, and representatives of the concessionaire or service.

The layout of ticket office, ticket-selling counter, baggage-storage area, loading dock, and baggage-checking counter should be developed on the basis of the actual furniture and equipment to be installed and the required working clearances. In designing the ticket and baggage counters, consideration should be given to automated ticket selling and baggage-handling equipment.

Many railroads combine the ticket-selling and baggage-checking functions. This is done in several different ways, and the counters should be designed to accommodate the proposed work flow determined by those responsible for establishing job functions. The number of positions required should be a part of this same work-flow study.

Adequate, paved, well lighted and protected parking areas should be provided so that train travelers can park their cars overnight or for several days while they are away.

Traffic lanes and pedestrian platforms should be provided convenient to the entrance to the passenger station so that patrons can safely load or unload from passenger cars or cabs. Separate parking lanes should be provided where unoccupied cabs can wait. Loading zones or service drives for trucks serving concessionaires should not be overlooked.

Station platforms should be of sufficient length to provide access to all head-end cars as well as to passenger cars on the longest trains that will be serviced from the platform. Platform widths should be adequate for the handling and turning of mechanized equipment as well as providing safe clearance for passengers and equipment.

The requirement for station-platform canopies must be based on economic justification as well as traffic load.

The problem of handling cross-track traffic to island platforms—whether by subway, overhead bridge, or at grade—must also be resolved on the basis of economic justification as well as both passenger and rail-traffic load.

No report on the design of passenger stations would be complete without touching on the subject of signs, and here again the complexity of trying to establish a standard design approach is apparent. Signs will range in type from the station-location and railroad-identification signs through all types of directional and advertising signs, including parking-lot and driveway signs. In many cases signs may be used aesthetically as part of the design. Some railroads are using large identification signs in their parking lots similar to those used by shopping centers.

In the foregoing, no attempt has been made, nor should be made, to discuss specific construction methods or materials, or specific designs for heating, electrical or mechanical equipment, as these items are covered in many good design manuals which are readily available. Furthermore, decisions concerning the specific details of these items should be made by the individual architect or engineer based on his company's management policies.

Pages 6–20–4 and
6–20–5

LOCATION AND DESIGN OF SIGNS FOR PASSENGER STATIONS

Delete.

Report on Assignment 2

Specifications for Railway Buildings

C. R. Madeley (chairman, subcommittee), W. F. Armstrong, E. P. Bohn, A. C. Cayou, A. W. Charvat, F. D. Day, A. R. Gualtieri, J. W. Gwyn, E. J. Hynes, R. E. Lilliston, D. F. Logan, W. H. Macauley, Jr., G. A. Morison, C. L. Robinson, J. T. Rowan, T. H. Seep, L. D. Smith, R. C. Smith, M. L. Thornbrough.

Your committee submits as information the following recommended practice with respect to portable station buildings.

The ever-changing methods of operation, abandonment of service and reduced LCL service have antiquated many station buildings. This has brought about the need for a more compact facility which may be relocated at minimum expense.

The concept of a moveable or portable building is not new, but because of the wide variance of opinion as to just what a portable building is compared to a permanent building, it was felt that general specifications for portable station buildings should be provided as a guide to those wishing to take advantage of the economies offered by this type of structure.

PORTABLE STATION BUILDINGS

1. General

The word portable, by definition, means capable of being borne, or easily transported. A "portable" station building should, therefore, be one constructed as compactly as practical in such a manner as to provide a reasonable amount of flexibility in office and freight areas and be capable of being easily transported as required.

Justification for such a building is dependent on the following considerations:

(a) Type and volume of freight handled.
(b) Number of personnel involved.
(c) Future traffic forecast. Does it justify a permanent or temporary facility?
(d) Size and structural components of building. Do they permit the building to be transported either by rail or highway?
(e) Tax advantages that can be gained by replacing large facilities which are no longer required with a smaller, more compact building.
(f) Reduction in maintenance cost.

2. Materials

A portable station building should be constructed of material normally congruous with local policies, where practicable. Definite consideration should be given to required durability, maintenance cost, location economics, architectural requirements and relocation costs.

The entire structure should be properly designed and braced to withstand the abnormal forces that will be exerted on the building during loading, shipping and unloading operations. The substructure should incorporate "skid"-type members of a design, type and size that will facilitate moving, with proper distribution of the floor loads. Generally, three types of substructures may be used—timber, a combination of steel and timber, or a combination of steel and lightweight concrete (see Fig. 1). All timber used should be fire-retardant treated.

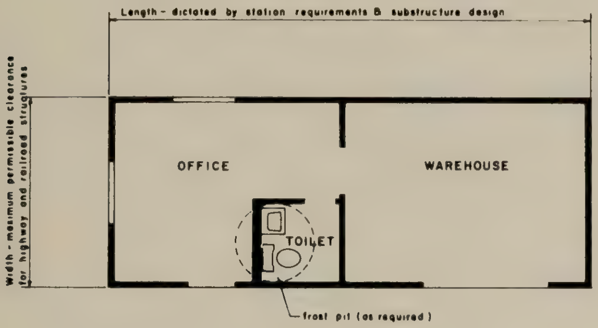
Superstructure materials may vary with location economics and architectural requirements. The use of the so-called standard metal building is increasing rapidly because of its inherent durability and economy, and the development of "sandwich" wall panels. It is important that the superstructure be designed and braced to withstand abnormal shipping forces.

3. Platforms

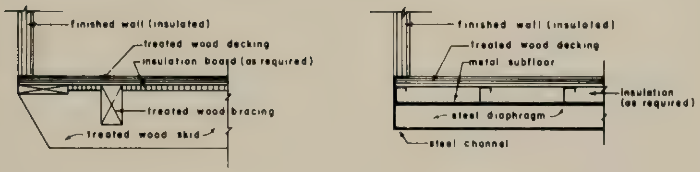
Where local conditions indicate the desirability of an outside platform or platforms, they should be consistent with floor loadings for that location. All outside platforms should be constructed separately and independently from the building proper, and be adequately braced for truck impact.

The height of platforms, doors, platform protection, platform slope and roof overhang or canopy at doors should conform with the recommendations set forth in Freight Houses, Part 20, this Chapter, where possible.

Where an overhang or a canopy is required, it should be detachable for shipping purposes.

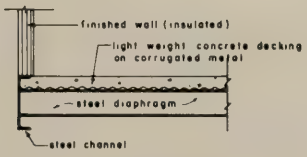

Length - dictated by station requirements & substructure design
Width - maximum permissible clearance for highway and railroad structures
OFFICE
WAREHOUSE
TOILET
frost pit (as required)

FLOOR PLAN



TYPICAL SECTION

ALTERNATE SECTION


finished wall (insulated)
light weight concrete decking on corrugated metal
steel diaphragm
steel channel

ALTERNATE SECTION

Fig 1

PORTABLE STATION BUILDING

4. Lighting

Adequate lighting is needed for an efficient operation. The intensities of illumination should meet the minimum recommended for the various portions of a station by the Illumination Engineering Society.

Fixtures should be selected which will give the desired intensity and quality of properly diffused light without glare. Diffused fluorescent lighting for office areas is recommended and should be so designed as to give an even distribution of illumination throughout the office area. Consideration should also be given to utilizing fixtures throughout the station with interchangeable lamps so as to reduce stocking of many different sizes of lamps and ease of relamping.

Sufficient exterior lighting should be considered, consistent with night-time operations. Receptacles should be provided at doorways for the accommodations of extension-cord lighting.

All wiring should meet the requirements of the National Electrical Code, minimum local codes and the National Board of Fire Underwriters.

For natural lighting in warehouse spaces, refer to Freight Houses, Part 20, this Chapter.

5. Heating

Because of the relatively small area of the office space, a forced-air wall heater with a Btu rating commensurate with local conditions is recommended. All natural-gas, manufactured-gas or oil-fired heating units should be properly vented in accordance with local codes. Where conditions warrant, electric heating may be the most economical and desirable.

6. Toilet Facilities

Suitable toilet and washing facilities should be provided and should be consistent with the use of the building and the personnel involved.

All plumbing should conform with the recommendations set forth under Plumbing, Part 14, this Chapter, and be governed by individual state and local codes covering sanitary facilities.

All fixtures, piping, vents, and connections should be designed and selected so as not to hinder movement of the building.

7. Tracks

Track clearances for platforms and buildings, as well as heights of platforms and floors above top of rail, should conform with the recommendations of Chapter 28—Clearances, or with state or other legal restrictions governing such clearances.

8. Special Shipping Procedures

To facilitate ultimate movement of the portable station building, consideration should be given to erecting the building on the ultimate means of transportation, size permitting.

Clearances of railroad structures and/or highway structures, and regulations for movement thereon, should be thoroughly checked. The building should be securely fastened to its means of transportation and inspected prior to shipment, and instructions issued for its inspection at terminal points enroute.

To avoid damage to interior accessories while the building is enroute, it is recommended that all accessories that are not permanently bolted, screwed or nailed in place, be crated, braced and secured prior to shipment.

Report on Assignment 3

Use of Synthetic Resins for Adhesives in Connection with Railway Buildings

H. A. Shannon (chairman, subcommittee), S. M. Bielski, E. J. Hynes, R. E. Lilliston, D. F. Logan, W. K. McFarling, L. S. Newman, C. L. Robinson, J. T. Rowan, L. Shedd, E. R. Shultz, L. D. Smith, R. C. Smith, M. L. Thornbrough, R. C. Turnbell, W. L. Burgess, R. R. Cahal, A. W. Charvat, O. C. Denz.

Your committee submits the following final report as information:

A. INTRODUCTION

The American Society for Testing and Materials defines an adhesive as a substance capable of holding materials together by surface attachment. The development of adhesives in which the major ingredient is a synthetic resin has reached the point where such adhesives have found acceptance in the building industry.

Elastomeric adhesives, either oil soluble or oil resistant, can often be used where mechanical fastening is not feasible. They also can be used to replace mechanical fasteners in many joining operations. Whenever materials must be fastened—whether plastics, cloth, insulation, metals, ceramics, plasterboard, wood, glass, rubber, cork, linoleum, curtain walls or floor and wall tiles—adhesives can be used. Even distribution of stresses is obtained, and there is no marring of surfaces or attachments.

Many structural adhesives which contribute to load-bearing capacity are being manufactured today. They are composed of a thermosetting modified epoxy resin and a latent type of hardening agent that will set or solidify upon the application of heat. They are 100-percent solids that contain no solvents, provide a smooth, solid, sealing bond at the adhesive line, and have no objectionable fumes or smells. New structural epoxy adhesives can be used to join aluminum, steel, iron, alloys, and ceramics, and plastics that can withstand the necessary curing temperatures. Minimum curing temperatures range from 200 to 335 F. Maximum curing temperature ranges from 400 to 450 F. Curing time varies from 3 to 120 min, depending on temperature and kind of materials. Structural adhesives are manufactured in four grades and require no mixing. Their relative bond strength varies from 5000 psi for aluminum to 1200 psi for plastics. The thickness of the adhesive coat ranges from 3 to 6 mils, according to ASTM specifications.

Protective coatings, generally used on metals, can also be used on plastics, wood, concrete and other surfaces. They serve three main functions—protection, sound dampening and insulation. Synthetic resin-based coatings are thin bodied and set to a much firmer dry film then others. They are flexible, yet tear resistant, tough and firm, resist gasoline, oil, rain and erosion, and provide excellent undercoating. Neoprene rubber-based coatings also have proved successful. They can be applied by brush, roller or spray gun to a thickness of 3 to 15 mils.

Synthetic sealers can be used to seal gaps after parts are assembled, or the sealers can be applied before assembling. Whenever a seal must be established against dust, air, water or fumes, various polysulfide sealing compounds or liquids can be used. They can be pressed into place by hand, brushed on or flowed on. Ribbon-type or non-tacky extruded sealer gaskets can be applied by hand. Caulking guns can be used for caulking joints of wall panels of curtain walls and masonry joints. Liquid polysulfide sealants can be applied to the joints of heating, ventilating and air-conditioning ducts, and insulation can be fastened to such ducts with a proper adhesive.

B. THE GENERAL CHARACTERISTICS OF SYNTHETIC RESINS

The characteristics of synthetic resins can be varied by changing their molecular arrangement or chemical formulation. The final product can be as brittle as glass, as resilient as rubber, a dense solid of high moleular weight, or a liquid of low molecular weight and of such viscosity that it will leak out of a container that will hold water. Almost all the synthetic resins now in use are based on petroleum processing and normally fall into the two following categories:

1. *Thermosetting Resins:* Those that cannot be softened by heat within their design range. In general, they are either cured by chemical reaction (catalyzation) or by the interlocking of their various chemical components. Due to their tight, dense molecular structure, the thickness of the coating remains constant from the time of application to the final cure. This is a distinct advantage over natural coatings and adhesives which cure or harden by the evaporation or oxidation of their solvents, with the result that the molecular structure is less densely packed and therefore less resistant to abrasion, corrosion, moisture and deterioration.

2. *Thermoplastic Resins:* Those that can be softened, remolded or reshaped as many times as desired by the application of heat. These resins in latex form have been used for quite some time as vehicles for interior paints and recently have been developed for exterior use. As adhesives, they are just beginning to demonstrate their usefulness. Coatings of these resins may be water based, solvent based or hot melts containing no volatiles.

C. THERMOSETTING RESINS

1. Urethanes

The use of urethanes as adhesives is relatively new; however, they have already demonstrated their ability to join two dissimilar materials together in a strong durable joint. They probably will be used in building adhesives as a component rather than the main ingredient.

As coatings, the urethanes rank among the best. They can be applied by brush, spray gun or other conventional means and are available in either clear or pigmented finishes. Resistant to abrasion, wear, chemicals, solvents, oils, water and weather, they are used as floor finishes, sealer coats (for all types of wood, including laminated timbers, both for interior and exterior use) and to seal concrete and other masonry surfaces.

Urethanes at present are being used in the manufacture of rigid-foam thermal insulation. They are being developed as a poured-in-place foam insulation and to prevent gaps forming between the foam and enclosing surfaces which would reduce the insulating efficiency. The adhesive qualities of this foam will necessarily have to be good.

2. Polyesters

This synthetic material is essentially the binder or adhesive used in the manufacture of fiber-glass-reinforced plastic and is both body and finish. Products fabricated from this material include furniture, boats and translucent and opaque panels in both flat and corrugated sheets. These sheets are used in the roofs and walls of industrial buildings to provide natural light as well as in the manufacture of room dividers and partitions.

As coatings, polyesters trail the urethanes. They recently have been used in the development of a glass-like porcelainized coating which has good resistance to abrasion, chemical stains and physical abuse. Due to application difficulties, however, the coating at present is limited to in-the-shop finishes. Prospective uses are in the prefinishing of wood panels, precoating of lumber and the porcelainizing of the exposed surfaces of cement blocks.

3. Epoxies

Adhesives in which eopxy resin is the prime ingredient are the most established adhesives for in-the-field application in the construction industry. They have the advantage of curing without pressure and at room or elevated temperature, do not shrink on application and can be applied by brush, spray or trowel. They can be used with or without aggregates, can be loaded up to five times their weight with sand or other inert fillers, and can be finished to a feather edge. They are used as a bonding agent for concrete and as a patching material for concrete or other masonry.

Epoxy coatings are recommended for application on metals and concrete, but are not recommended for wood or other surfaces which require coatings that are flexible and can "breathe." They are hard and exceptionally resistant to wear, chemicals, acids and weather. They have relatively poor gloss retention on outside exposures, and only fair color retention.

Problems in the use of epoxies, such as short "pot life," toxicity and application difficulties, are being resolved through new formulations and mixing techniques.

For further information on epoxy resins see AREA Proceedings, Vol. 64, 1963, pages 1 to 17.

4. Phenolics and Resorcinols

Phenolic resins are used primarily as adhesives in the manufacture of exterior plywood. Such resins require both high pressures and temperatures for curing.

Resorcinol resin, a sort of "super" phenol, is far more reactive than phenolic resin and cures at room temperature. It is used in the manufacture of laminated timbers. (Phenolic resin is not suitable for this purpose since it would require heating sections of lumber up to 1 in thick to permit the heat to reach the glue line, which is not very feasible).

5. Amino Resins

Urea formaldehyde is generally the adhesive used in the manufacture of interior plywood, wood paneling, fiber boards and other applications where the requirement for moisture resistance is not too severe.

Melamine formaldehyde is used in the manufacture of plastic facing (such as formica) for table tops, counter tops and similar applications.

6. Synthetic Rubbers

Neoprene rubber cements are used in applications where heavier-duty requirements preclude the use of natural rubber cements (natural and reclaimed rubber cements are primarily used for bonding plywood, floor tile, wall tile, etc., to their substrates). Applications include the bonding of sink and counter tops, acoustical tile and plastic wall coverings to their bases. These cements are also used as adhesives for sandwich-wall construction.

Polysulphide rubbers are, at present, the preferred sealants for curtain-wall construction. They are used as sealants for the joints in stone sills and copings, as well as the caulking in expansion joints for concrete and masonry construction. They are highly elastic in their cured state, resist distortion to a great degree and withstand long exposure to the weather exceedingly well.

Silicone rubbers have recently been introduced and are gaining acceptance as sealants in applications similar to those of the polysulphide rubbers.

D. THERMOPLASTIC SYNTHETIC RESINS

1. Vinyls

Compounds of this resin, such as polyvinyl acetate (in latex form) are used directly or blended with portland cement for the purpose of bonding concrete or other cementitious materials together. Suitably compounded, this resin also is useful for the bonding of polyvinyl chloride films to wall boards and plywood, in the lamination of aluminum foils, and as a tape joint cement for wall board.

As a synthetic coating, vinyl has been used for quite some time in the construction industry. After World War II, the Navy used this material as "cocoon" coating to "moth ball" its inactive fleet. It has since been used as a protective coating in high-humidity buildings, such as textile and pulp mills and chemical plants. As a film, it has been used to protect materials on the job site and as a vapor barrier. It has also been found suitable for use as a sprayed-on coating for waterproofing steel and concrete roofs where, because of expansion and contraction requirements or for esthetic reasons, a conventional roof coating could not be used. The major problem of this coating is its inability to breathe, so it is not recommended for coating surfaces such as wood or gypsum roof decks where this ability is one of the requirements.

2. Acrylics

Investigations have been conducted to develop the possibilities of this polymer as a sealant, with favorable results; however, to date the material has not had any commercial applications.

These resins are used as coatings for fabrics in conjunction with vinyls, as clear protective coatings on metals, in latex paint and as electrical insulation coatings.

E. CONCLUSION

It is important for the architect and engineer to have an understanding of the chemical terminology and implications of technical descriptions, since most adhesives are specified and created for specific job functions. There is no single adhesive that will do every job well, though there are thousands of adhesives that will do one job perfectly if they are correctly applied.

The existence of ASTM guides for these and other adhesive applications, and those issued by the government and such industrial organizations as the Adhesive and Sealant Manufacturers Council and the National Association of Architectural Metal Manufacturers, offer the engineer and architect the assurance that these advanced structural products will perform effectively. It remains for the architect and engineer to take advantage of the available information.

BIBLIOGRAPHY

Dr. Irving Skeist, Survey of Adhesives, AIA File No. 24A and Handbook of Adhesives and Epoxy Resins

Rubber, Plastic, Adhesive and Sealant Manufacturing Council, Minnesota Mining and Manufacturing Company.

Report on Assignment 4

New Advances in Paint and Coating Products for Railway Buildings

A. F. Langmeyer (chairman subcommittee), J. H. Adams, Jr., F. R. Bartlett, W. L. Burgess, R. R. Cahal, J. W. Gwyn, W. R. Hyma, E. J. Hynes, H. J. Lieser, D. F. Logan, W. H. Macauley, Jr., W. K. McFarling, L. S. Newman, L. H. Nichols, E. R. Shultz, R. C. Smith, M. L. Thornbrough, Jr., R. C. Turnbell.

Introduction

In recent years, a multitude of new paint coatings have appeared on the market, making it increasingly difficult to decide upon which coating to use for a specific purpose.

In the immediate postwar years such synthetic-based coatings as alkyds and latexes were the most prominent new products. Alkyd synthetic resin was not really new, having been developed in the early 1930's, but it did not make any noticeable inroads into the market until after World War II. Today, alkyd resin is the most versatile and widely used of the synthetic resins and is rapidly replacing linseed-oil-base paints. The alkyds and latexes are now quite common, and it is no longer difficult to decide where to use them.

The new products that have recently appeared on the market and are being referred to in technical publications have such names as epoxy, polyester, vinyl, urethane and hypalon. Like the alkyds, these are synthetics and form the base of a variety of new coatings. When properly used and applied, these new coatings will successfully cover many areas that pose problems for the more conventional paints. This feature, coupled with their durability will more than offset the relatively high costs of these new products.

The urethanes, polyesters, and epoxies possess one characteristic which differentiates them from all other coatings—they are all catalized or thermosetting-type coatings. While conventional oil-base paints harden by oxidation, and lacquers by evaporation of their solvents, the above synthetic resins cure or set by a chemical reaction or an interlocking of the molecular structure of the various chemical components. This reaction takes place between the resin and a catalyst, and in the preparation of these coatings little or no solvent is used. In the latter case the coatings are referred to as a "100-percent-solids" system. While it is more difficult to apply a mixture of this type, its importance lies in the fact that the wet mil thickness is retained upon drying (curing) because no evaporation takes place.

The key to the success of these thermosetting resins in generally outperforming conventional paints with respect to resisting the action of weather, abrasion, corrosion, etc., is the dense molecular structure of the material after setting.

The following is a brief description of the uses and characteristics of these synthetic resins.

Epoxy

Of all the new thermosetting synthetic resins, the epoxies have been the most publicized. They are one of the three resins classified as a 100-percent-solids system.

Their outstanding characteristics are: good resistance to chemicals, acids and moisture; an extremely hard surface; and excellent adhesion to various substrates. They do not shrink (because of their 100-percent-solids base), set rapidly, and are easily applied by spray gun, brush, or roller. They are prepared in one- and two-component systems and vary in consistency from liquid to paste-like. They are used with or without aggregates and can be pigmented.

Some of the disadvantages are: Relatively short pot life, inflexibility, inability to "breathe," strong odor, and a tendency to cause skin irritation.

The most durable of the epoxies for the widest range of conditions are the two-component systems, using 100-percent epoxy solids. Manufacturers of these systems claim—and point to the record in support of their claims—a finish 40 to 50 times more resistant to wear than ordinary paints.

When mixed with sand (preferably silica sand), epoxy is used for patching concrete or applying an extremely durable and impervious wearing surface to concrete floors. It can be applied as thinly as ⅛ in and feathered out where desired. In its liquid state, it is used as a bonding agent between old and new concrete, being brushed on the surface of the old concrete prior to pouring the fresh concrete. Epoxy-coated concrete block has been used in place of ceramic tile in gymnasiums, shower rooms, etc. Pigments are usually added to the epoxy for this purpose.

Consideration should be given to using epoxy on concrete, masonry and steel when resistance to abrasion and chemical action is a factor. Because of its inflexibility and inability to "breathe," it is not recommended as a coating for wood.

Cleaning of tools is an important factor after being used to apply epoxy coatings. If the epoxy is permitted to set in brushes or spray equipment, the tools will be rendered useless, since there is no known solvent that will dissolve a cured epoxy coating without destroying the materials of which the tools are made.

Polyester

Polyester is another of the synthetic resins that fall in the 100-percent-solids-system category. Because of difficulties in applying this material under field conditions, its use is presently limited to shop application. Upon setting, this material presents a glossy, porcelainized finish. This, along with its ability to resist stains and damage from impact and abrasion, makes it an excellent coating for furniture, which is its principal use today.

Experiments using this material for prefinishing wood paneling look promising. It is also being used to laminate murals, fabrics and other materials to flush-panel doors in clear finish to produce striking decor concepts. Another possible use being considered is a shop-applied porcelainized coating on concrete blocks and metal panels.

Vinyl

Vinyl coatings were first extensively used as a protective coating against weather by the U. S. Navy after World War II when its inactive fleet was put in "moth balls." As an outgrowth of this, research was carried on for the purpose of determining the potentialities of this material as an exterior coating for buildings, especially roof surfaces.

Vinyl coatings are most commonly applied to metals. As an example, the steel roof of the Squaw Valley Ice Arena, where the 1960 Winter Olympics were held, is coated with a sprayed-on vinyl membrane. This application has been very successful because it allows the huge steel roof to expand and contract with the extreme temperature changes without rupturing the roof membrane. The value of vinyl roof coatings is more fully realized when used on the irregular roof surfaces of the contemporary structures being erected today. Its flexible nature has eliminated many of the difficult flashing problems encountered when conventional roofing materials are used.

Vinyls are also being used as shop coatings on aluminum siding. They are pigmented for this purpose.

Vinyl coatings have been applied to concrete structures with some success. Such a coating was sprayed on the Guggenheim Museum, and with the exception of some blistering and hairline cracks at the construction joints, it has performed satisfactorily.

Because of its inability to "breathe," vinyl is not recommended as a coating where moisture is a factor. With a special formulation and special insulation, it has been tried on a few folded plywood roof decks, but these applications are still too new to measure their value.

Urethane

Urethane is the third member of the 100-percent-solids system. It is used as a coating on both concrete and wood, most commonly on the latter. Its ability to resist abrasion, weather action, and chemical corrosion, plus its flexibility and "breathing" characteristics, make it an excellent coating.

It is easily applied with spray gun, brush or roller. In some instances it is pigmented, but it is most commonly applied as a clear coating over wood floors, interior trim and paneling, wood siding, and as a sealant on glue-laminated beams.

Of all the new coatings, urethane appears to be the most promising for use as an exterior wood coating and, in many respects, appears to be superior to spar varnish.

Special formulations of this material are also applied over concrete floors to provide an abrasion-resistant and chemical- and acid-resistant surface. Test data indicate that this material has 40 times the bonding strength of concrete, twice its compressive strength, and 16 times its impact and abrasion resistance.

Wall applications of urethane compounds offer results nearly as remarkable—less spectacular only because few walls sustain anywhere near the abuse given floors. Applied by brush, roller, spray gun, trowel or squeegee, a finish equivalent in thickness to 100 coats of paint can be applied by painting contractors or maintenance crews, producing a surface that is unaffected by impact, steam-jet cleaning, strong detergents, and condensation of fats, oil and moisture.

Hypalon

Hypalon is a synthetic rubber and is used either alone or, more often, over a neoprene prime coat, the reason for the latter being that neoprene is cheaper than hypalon. Hypalon has characteristics similar to vinyl although, generally, it has a longer life. Like vinyl, its primary use is as a waterproof coating on roofs and walls. It is important that the surface to which it is going to be applied be clean, dry and fairly smooth. It will not fill nor conceal more than hairline cracks and form marks in concrete. A proper application of this material requires that fabric tape or flexible plastic flashing be applied along all expansion joints, construction joints and flashing lines. It can be applied with either spray gun, brush, or roller over concrete, plywood, asbestos cement board, fiberboard and metals although, like the vinyls, its most desirable use is over metal or concrete. Hypalon coatings come in a wide variety of colors, have good color retentivity and have good resistance to oxidation and deterioration.

Fire-Retardant Paints

Both of the two main types of fire-retardant paints are non-combustible and generate gas (CO_2) when heated. In one type the gas is believed to smother the flame and prevent the substrate from igniting. In the other type, called intumescent, gas formed swells the paint to a thickness 200 times that of its original thickness. This thickened film becomes rigid and filled with small air spaces and acts as an insulator, thus preventing or delaying the ignition of the substrate.

One manufacturer of an intumescent-type coating has an Underwriter's Laboratories flame-spread classification of 25 on its product when applied in one coat over wood or acoustical tile. For two-coat coverage, its classification is 10. This compares with a classification of 100 for unpainted red oak.

These paints are available in a wide range of colors. A clear coating is also available, but its flame-spread classification is only 70.

After the intumescent-type coating has been exposed to fire, the thickened coating is easily removed with a scraper and the undamaged surface is ready for immediate repainting.

CONCLUSIONS

While these new coatings are by no means the answer to all coating problems, they are an indication of the paint industry's constant effort to improve their products. The performance of any field-applied coating still depends mainly on proper preparation of the surface to which it is going to be applied.

The following table is a generalization of the uses and characteristics of the new synthetic-resin coatings described in this report.

New Coatings—Characteristics and Uses

	Urethanes	*Polyesters*	*Epoxies*	*Vinyls*	*Hypalon*
1. Flexibility	Fair	Fair	Poor	Excellent	Excellent
2. Breathability (Resistance to Blistering or Peeling from Water Vapor Transmission)	Good	Good	Poor	Poor	Poor
3. Abrasion Resistance	Excellent	Fair	Good	Fair	Fair
4. Water Resistance	Excellent	Good	Good	Excellent	Good
5. Chemical Resistance	Good	Good	Good	Excellent	Good
6. Weather Deterioration Resistance	Good	Good	Fair	Good	Good
7. Impact Resistance	Fair	Excellent	Fair	Good	Good
8. Adhesion	Fair	Good	Excellent	Fair	Fair
9. Color Retention	Fair	Excellent	Fair	Good	Excellent
Recommended Uses	Wood, Concrete	Wood, Metals	Concrete, Metal, Masonry	Metal, Concrete	Concrete, Masonry, Wood

Report on Assignment 5

Prestressed Concrete for Railway Buildings

Collaborating with Committee 8

W. R. Hyma (chairman, subcommittee), G. J. Bleul, R. E. Lilliston, G. H. McMillan, G. A. Morison, L. J. Nichols, W. C. Panarese, J. T. Rowan, H. A. Shannon, Jr., Loren Shedd, T. S. Williams

Your committee submits the following final report as information.

A. INTRODUCTION

Definitions

The American Concrete Institute's Committee on Prestressed Concrete defines it as "Concrete in which there have been introduced internal stresses of such magnitude and distribution that the stresses resulting from given external loadings are counteracted to a desired degree. In reinforced concrete members the prestress is commonly introduced by tensioning the steel reinforcement."

Prestressed concrete can also be termed precompressed concrete. Since concrete itself is strong in compression but relatively weak in tension, precompressive forces are applied prior to loading in such a way as to offset the tensile stresses experienced under load.

Classification

Prestressed concrete members can be described or categorized in several ways. The most common classification is according to the time of prestressing. If the steel tendons are tensioned prior to the placement of the concrete, the member is said to be pretensioned, while if the tendons are tensioned after the concrete has hardened, the member is described as post-tensioned. In the case of post-tensioned elements, the tendons are almost always anchored at the ends by various mechanical means, although they may subsequently be bonded to the concrete by grouting as a protection against corrosion. In the pretensioned members the tendons are generally limited to relatively small wires and strands, and are not anchored but transmit the prestress directly to the concrete through bond action.

Prestressed units cast at a central yard or plant, transported to the site, and erected are described as precast, while units formed and cast in their final position in the structure are said to be cast-in-place. Composite construction utilizes both precast and cast-in-place elements.

A final means of distinction is according to the configuration of the prestressing tendons. Tendons wound in circles as in pipes, silos, tanks, etc., make up circular prestressing, while the tendons in other structural elements, such as beams and slabs, are described as linear prestressing even though they may be curved or draped.

History

The earliest applications of the concept of prestressing concrete are obscure, but it is recorded that a California engineer, P. H. Jackson, obtained patents on a system of tightening steel rods through artificial stones to form floor slabs in 1886. Two years later in Germany, C. E. W. Doehring secured patents for concrete reinforced with metal having tensile stresses applied prior to loading. Neither of these methods were particularly successful, however, because the relatively small amount of prestress in the mild steel was soon lost through creep and shrinkage. In an effort to meet this problem, C. R. Steiner of the United States in 1908 offered a method of retightening the reinforcing bars after most of the shrinkage and creep had taken place. In 1925, R. E. Dill of the United States used high-strength steel bars for reinforcement which he coated to prevent bond to the concrete. The rods were tensioned after the concrete had set and were anchored with threaded nuts. Due to its high cost, however, this method also found little acceptance.

The greatest impetus to the development of a practical system of prestressing came from the work of E. Freysinet of France who started using high-strength steel wires for prestressing in 1928. With a yield point of approximately 180,000 psi, the wires were tensioned to around 150,000 psi, leaving an effective prestressing force of over 125,000 psi after losses. Freysinet worked with both pretensioned and post-tensioned systems, but a German, E. Hoyer, is generally credited with developing the first practical system of pretensioning. In the late 1930's and early 1940's several practical end-anchorage systems for post-tensioned work were perfected, the most widely accepted being those of Freysinet and G. Magnel, a Belgian professor.

Based principally on the work of these two men, France and Belgium led in the development of prestressed concrete as a structural material following World War II, but England, Germany, Holland and Switzerland quickly followed suit and made important contributions.

Development in the United States was along somewhat different lines. Instead of linear prestressing, circular prestressing took the lead, primarily in the work of the Preload Company which developed special wire-winding machines. Between 1935 and 1953, over 700 circular tanks were constructed by this system in this country and abroad. The first major linear prestressed structure in the United States was the Walnut Lane Bridge in Philadelphia, Pa. Begun in 1949, it is a 160-ft post-tensioned highway span utilizing the Magnel system of end anchorage. The first pretensioned beams in this country were cast in 1951 for a 24-ft highway bridge near Hershey, Pa. The first prestressed railway bridge in the U. S. was constructed on the Burlington in 1954.

The more rapid growth in Europe can be attributed to the major rebuilding task facing most of the European countries following the devastation of World War II, coupled with critical material shortages. Structural steel in particular was scarce and expensive, while labor costs were still quite low.

Acceptance in this country was somewhat slower initially, but has since developed rapidly as the physical capabilities were proven in Europe. Rising steel costs, material shortages during the Korean conflict, the expanded highway construction program, and the development of mass-production methods to minimize labor costs have all been factors in the expansion of the use of prestressed concrete here in recent years.

B. ADVANTAGES, OR INDICATIONS FOR USE

Physical Properties

The proper combination of the compressive resistance of high-strength concrete and the tensile resistance of high-strength steel gives prestressed concrete certain desirable physical characteristics not inherent in ordinary reinforced concrete. First, since at service load the entire cross section is effective in compression rather than just the section above the neutral axis, the members can be shallower with longer spans. Dead loads are reduced, there is less deflection, and the prestressed member has greater rigidity in relation to its size. Longer cantilevers are possible, as are larger unobstructed areas.

Secondly, precompression tends to reduce diagonal tension. Thus, external shears can be carried by smaller sections; webs can be reduced in thickness; and less secondary reinforcement is required.

Another physical advantage of prestressed concrete is that it is free of flexural cracks at working load. This feature results in improved appearance, better resistance to corrosive elements, leak-proof surfaces and an ability to withstand handling during erection.

Prestressing is ordinarily arranged to produce an initial camber in linear sections, offsetting dead-load deflections and giving an improved appearance.

In the area of safety it is unwise to generalize, since the design and construction of a member play decisive roles. However, it can be said that in prestressed concrete construction there is a partial testing of both the steel and the concrete during the prestressing operation. Often the materials are subjected to the highest stresses during this stage that they will ever experience. In ordinary designs, the large deflections as the ultimate load is approached give adequate warning before failure. The closer quality control usually associated with high-strength materials is another plus feature for prestressed concrete.

Economic Considerations

The economies of prestressed concrete are of course directly related to the physical characteristics. Thus the smaller, lighter sections lead to reduced story heights with resultant savings in columns and wall closures. The reduction in weight leads to smaller columns and thinner walls, with smaller footings, as well as to reduced transportation and erection costs. It should be noted here that railroads have some unique advantages when considering prestressed concrete. The reduction or elimination of transportation charges gives a railroad a much larger supply area from which to buy, and at the same time improves the economic position of prestressed concrete in relation to steel and other metals having a higher strength-to-weight ratio.

The absence of cracking coupled with the greater durability of high-strength concrete contribute to long life and low maintenance costs. Also, the appearance is often such that framing members can be left exposed, and surfaces of slabs and wall panels require no further treatment.

The precasting of most prestressed concrete allows faster erection and the elimination or reduction of field delays due to adverse weather. Precasting also results in more accurate scheduling and better coordination with other trades, all of which lowers erection costs.

Comparing the material costs of prestressed concrete with those of conventional structural concrete, high-strength strand costs about 3 times as much as ordinary mild-steel reinforcing but is up to 6 times as strong. Similarly, the high-strength concrete employed for prestressing costs perhaps 20 percent more than regular concrete, but has double the strength. Thus, the cost of a structural member in dollars per ton of load resistance is lower in prestressed concrete, other factors being equal.

C. DISADVANTAGES, OR LIMITATIONS ON USE

Design

To realize many of the advantages of prestressed concrete, a more rigorous and costly design procedure is often required. At the same time, a lack of familiarity on the part of many designers has sometimes led to over-conservatism, unnecessarily high estimates, or a tendency to stay with more conventional materials. This lack of familiarity is compounded by the absence of complete standardization of sections and details compared to long-established materials of construction.

The fact that many designers are more familiar with other types of construction works to the disadvantage of prestressed concrete in another way. The general layout of the structure in regard to proportions and span lengths may fail to utilize the characteristics of prestressed concrete to best advantage. The longer spans, smaller sections, cantilevered members, etc., may be overlooked in the initial planning.

As is true of all newer materials, the difficulty in securing adequate and reliable cost information hampers the designer and slows acceptance.

Construction

While it is true that the closer quality control generally associated with the use of high-strength materials can be an advantage, it can also be a disadvantage from the standpoint of requiring more supervision.

Formwork for prestressed concrete is often more elaborate and can be very costly unless there is considerable reuse. Similarly, accessories, erection details and procedures can be difficult and expensive.

Just as unfamiliarity on the part of designers can be detrimental, the same unfamiliarity on the part of contractors in certain areas can lead to unnecessarily high bids and inefficient practices.

The use of prestressed concrete is rapidly becoming fully acceptable under most building codes, but in a very few instances it is still necessary to follow special procedures in order to obtain approval. The cost and delay thereby incurred could preclude the consideration of prestressed construction.

The desire to lower costs has sometimes resulted in substandard workmanship in regard to tolerances and finish. Users of mass-produced standard sections have complained of the lack of uniformity in length, size, camber and alinement. Surfaces to be left exposed have been chipped, stained with form oils or have varied in color to an objectionable degree.

D. CURRENT DEVELOPMENTS

Most prestressed concrete in buildings thus far has taken the form of beams, girders, floor and roof slabs, and piling, but the method is proving advantageous for a wide range of building components and construction techniques.

The use of prestressed concrete wall panels has risen sharply in the past five years. Standard double-tees and cored slabs have been used successfully with and without special exterior architectural treatment. Curtain-wall panels, as well as load-bearing panels, are now being prestressed. The advantages include elimination of possible shrinkage cracking and panel warping, use of thinner sections and larger panels without the problems of excessive handling stresses during erection.

Precast, prestressed trusses of many shapes and sizes have proven economically competitive in Europe and are gaining acceptance in this country. They can be cast in single large pieces or as multiple units that are later assembled, post-tensioned and lifted into place at the job site. Prestressed Vierendeel trusses with parallel top and bottom chords have been used in a number of building projects in the U. S. where spacious column-free bays were desired.

The technique of prestressing concrete lift slabs has evolved as an ingenious means of providing minimum thickness floor systems with reduced forming and shoring costs. The slabs are usually post-tensioned flat plates or waffle slabs. Generally the construction sequence is as follows: After the columns are erected, the floor and roof slabs are cast at ground level, separated by paper or other bond breakers. After the slabs attain sufficient strength, the prestressing wires are stretched, and hydraulic jacks, one on top of each column, hoist the slabs into place where they are welded to the columns by means of steel inserts cast into the components.

Prestressing is being used extensively in combination with thin-shell concrete roofs, including barrels, folded plates, domes and hyperbolic paraboloids. Longer spans are possible, and deflections are minimized, if not eliminated. When properly prestressed, a shell roof can be built without cracks, making the addition of roofing unnecessary.

Application of the principles of prestressing to concrete pavement slabs is very new in the U. S., and projects have been small and experimental in nature. In Europe, however, at least ten countries have placed prestressed pavements in operation since World War II.

Many new developments have taken place in prestressed piles, lighting standards, and electrical transmission poles and towers. The predominant advantage of prestressed piles is their ability to withstand severe handling and driving abuse. Prestressed poles and lighting standards are now being cast by a spinning process that produces a dense, very high-strength impervious concrete.

Methods of manufacture and erection of prestressed concrete are constantly improving. Recent developments include the extrusion of structural elements, and composite construction with precast-prestressed and cast-in-place concrete.

Several companies are now mass-producing prestressed hollow-cored floor and roof slabs by an extruding process. The extruding machine needs no rails or forms, only a flat bed to run on. Slabs several hundred feet long are extruded around the previously tensioned steel strand, and later sawed to required lengths.

Composite concrete structures combine the economy and efficiency of mass-produced, high-strength prestressed elements with the advantages of continuous monolithic structures hitherto cast-in-place at the job site. For connecting precast columns and floor elements, specially designed post-tensioning units are being used to develop rigid-frame action at the connection.

More than 60 standard fire tests have been conducted in the U. S. on prestressed concrete building components by four agencies: the National Bureau of Standards, Underwriters' Laboratories, Portland Cement Association and the Fire Prevention Research Institute. The mass of data compiled during these tests, as well as from tests conducted in Europe, indicates that the most important factors affecting the fire resistance of prestressed concrete flexural members are (1) thickness of concrete cover over the prestressing steel, (2) degree of end restraint of the member, (3) size of the cross section of the member, (4) shape of the member, (5) type of aggregate used in the concrete, and (6) moisture content of the concrete. The tests have proven that prestressed concrete structures can be designed to resist fires lasting up to 4 hr, and these results have been substantiated by actual experience in more than nine known fires.

Recent laboratory and field experiments have been conducted on chemical prestressing of concrete elements. In this technique, the high-strength steel is placed under tension by action of an expansive-cement used in the concrete. Although the art and techniques involved are yet to be fully developed, the use of expansive concrete holds great promise in the prestressing field for economical production of pressure pipe, precast thin shells elements, wall panels and pavements.

E. SPECIFICATIONS

The 1963 edition of the American Concrete Institute's "Building Code Requirements for Reinforced Concrete (ACI 318–63)" now includes a chapter on prestressed concrete, and, along with the Prestressed Concrete Institute's "Standard Building Code for Prestressed Concrete (STD 110–61)," serves as the principal guide to the design and construction of prestressed concrete building members. Earlier publications referred to extensively have been the 1958 ACI-ASCE Joint Committee 323 report "Tentative Recommendations for Prestressed Concrete," and the 1957 PCI "Standard Specifications for Pretensioned Concrete" and "Standard Specifications for Post-Tensioned Concrete."

Still needed are specifications covering workmanship and erection of prestressed members. The "Manual for Inspection of Prestressed Concrete" prepared by a joint PCI-AASHO committee and the report of the PCI Workmanship Committee on tolerances, both published in the December 1962 issue of the PCI Journal, are aimed at these problems.

Many of the various city and regional building codes, including the Uniform Building Code and the Southern Building Code, now include prestressed concrete construction, and the prestressing industry in particular is actively working toward universal code acceptance.

F. AVAILABILITY

Sources of Supply

At the present time there are about 325 plants in the United States and Canada engaged in the manufacture of prestressed concrete products. While the heaviest concentrations in this country are in the Southeast and Southwest, almost all states are represented. The PCI and PCA maintain comprehensive lists of the manufacturers and their products, and some areas have producers' organizations that can be contacted for information.

Precast Sections

While there are as yet no industry-wide standards for prestressed members comparable to rolled structural steel shapes, most of the manufacturers do produce some standard building sections. The most common of these is the double tee used principally for roof and floor slabs spanning up to 60 ft. Popular because it covers a large area per unit handled and because it can be cantilevered efficiently, the double-tee section can be left exposed on the underneath surface, and any necessary top surface treatment can be applied directly. The channel section is used in a similar manner and is also commonly available.

The single-tee section is economical in many instances because varied sizes, spanning as much as 150 ft, can be produced with one set of adjustable forms. Particularly interesting exposed-ceiling effects and long cantilevers have been achieved with the single tee.

For members of medium to long span where depth is not too critical, many I-beam sections are available for buildings as well as bridges. These members are often used in conjunction with cast-in-place slabs. Wide-flanged I-beam sections for long spans and heavy loads are produced in some areas.

A wide variety of cored slabs are generally available for use in roofs, floors, walls and platforms.

A majority of the prestressing plants can produce 10- to 24-in square and octagonal pile sections, both solid and hollow, in accordance with the standard plans prepared by a joint AASHO-PCI committee. Several producers, particularly on the West Coast, have developed standard pile sections of their own, including round and triangular shapes, which they make and stock in various lengths.

G. REFERENCE MATERIAL

Textbooks

A great many textbooks are now available on the subject of prestressed concrete, a few of which are listed below.

1. "Principles and Practices of Prestressed Concrete," by P. W. Abeles.
2. "Prestressed Reinforced Concrete," by Kurt Billig.
3. "Prestressed Concrete Structures," by A. E. Komendant.
4. "Prestressed Concrete," by Y. Guyon.
5. "Prestressed Concrete Design and Construction," by F. Walley.
6. "Design of Prestressed Concrete," by T. Y. Lin.
7. "The Theory of Prestressed Concrete Design," by H. J. Cowan.
8. "Prestressed Concrete," by R. H. Evans and E. W. Bennett.
9. "Prestressed Concrete Simply Explained," by H. Kaylor.
10. "Practical Prestressed Concrete," by H. K. Preston.
11. "Prestressed Concrete," by Gustave Magnel.

TABLE 1—PARTIAL LIST OF PRESTRESSED CONCRETE USED IN RAILWAY BUILDINGS

Railroad	*Type of Member*	*Location in Structure*	*Type of Structure*	*Location of Structure*
ACL	Double Tee	Roof	Warehouse	Ft. Myers, Fla.
ACL	Double Tee	Roof	Warehouse	Orlando, Fla.
ACL	Double Tee	Roof	Warehouse	St. Petersburg, Fla.
ACL	Double Tee	Roof, Floor	Freight Station	Tampa, Fla.
ACL	Channel	Roof	Yard Office	Charleston, S. C.
AT&SF	Joists*	Floor	Office Building	Wichita, Kan.
AT&SF	Channels	Roof, Floor	Trucking Garage	Wichita, Kan.
B&M	I-Beams	Roof	Car Service Shop	Somerville, Mass.
C&O	T-Pylon	Support	Control Tower	Newport News, Va.
C&O	Slabs	Roof, Floor	Control Tower	Newport News, Va.
C&O	Slabs	Roof, Wall	Washroom	Barboursville, W. Va.
CB&Q	Slabs	Roof, Floor	Freight Office	N. Kansas City, Mo.
CRI&P	Slabs	Roof, Floor	Switch Tower	Kansas City, Kan.
C&WI	Beams	Roof, Floor	Yardmaster's Tower	Chicago, Ill.
C&WI	Beams	Roof	Tool House	Hammond, Ind.
CNR	Slabs	Roof	Research Building	Montreal, Que.
CNR	Panels	Walls	Car Repair Shop	Toronto, Ont.
FEC	Double Tee	Roof	Freight House	St. Augustine, Fla.
FEC	Double Tee	Roof	Freight House	Ft. Lauderdale, Fla.
FEC	Double Tee	Roof	Freight House	Miami, Fla.
FEC	Double Tee	Roof	Freight House	Ft. Pierce, Fla.
FEC	Slabs	Platform	Freight House	Miami, Fla.
FEC	Slabs	Roof	Station	St. Augustine, Fla.
FEC	Double Tee	Walkways	TOFC Facilities	At six locations
LI	Stairs, Spans*	Complete Structure	Overhead Walk	Syosset, N. Y.
LI	Stairs, Spans*	Complete Structure	Overhead Walk	Pt. Washington, N. Y.
LI	Double Tee	Platforms (381)	World's Fair Grounds	New York, N. Y.
MC	Slabs	Roof	Yardmaster's Office	Bangor, Me.
MC	Slabs	Roof, Floor	Station	Waterville, Me.
MP	Double Tee	Roof	Diesel Shop	Kansas City, Mo.
NYNH&H	Slabs	Roof	Warehouse	North Haven, Conn.
N&W	Piles	Foundation	Coal Pier	Norfolk, Va.
NP	Cored Slabs	Roof	Yard Tower	Pasco, Wash.
NP	Cored Slabs	Roof	Freight Office	Aitkin, Minn.
NP	Cored Slabs	Roof, Floor	Depot	Spokane, Wash.
NP	I, Double Tee	Roof	Warehouses (2)	Seattle, Wash.
SAL	Double Tee	Roof	Station	St. Petersburg, Fla.
SAL	Double Tee	Roof	Station	Savannah, Ga.
SAL	Double Tee	Roof	Yard Office	Brooksville, Fla.
SAL	Beams, Tees	Roof	Freight Station	Tampa, Fla.
SOO	Cored Slabs	Roof	Yard Office	Minneapolis, Minn.
SP	Slabs	Roof	Diesel Shop	Eugene, Ore.
UP	Tees	Roof	Freight Station	Los Angeles, Cal.
WP	Piles, Frames	Support	Yardmaster's Tower	Stockton, Cal.

*Cast-in-place, post-tensioned. All other members are precast and pretensioned.

Other Publications

In addition to the textbooks, there is a great wealth of material relating to all phases of prestressed work in various technical publications such as the ACI Journal, PCI Journal, ASCE Transactions, Concrete Industries Yearbook and various PCA releases. Periodicals such as Engineering News-Record, Civil Engineering, Concrete and the Magazine of Concrete Research devote considerable space to developments in prestressing. Another valuable source of both general and specific information is the multitude of papers and bulletins coming from universities, trade organizations, engineering societies and conferences, both national and international.

H. USE IN RAILWAY BUILDINGS

To develop the extent to which prestressed concrete construction has been employed in railway buildings, a questionnaire was sent to 75 Class I Railroads. Replies were received from 55 of the roads, with 35 of them reporting no use to date. The other 20 reported using prestressed elements of some kind in a total of 51 structures dating back to 1953.

In 9 of the structures, the prestressed elements were designed by railroad personnel. Of the 51 structures reported, 1 was built in 1953, 1 in 1954, 1 in 1955, 3 in 1956, 5 in 1957, 9 in 1958, 9 in 1959, 4 in 1960, 2 in 1961, 10 in 1962, and 6 in 1963.

Detailed information derived from the questionnaire is shown in Table 1.

Report on Assignment 6

Use of Plastic Materials in Railway Buildings

H. R. Helker (chairman, subcommittee), W. F. Armstrong, A. C. Cayou, A. W. Charvat, J. S. Cooper, F. D. Day, V. E. Elshoff, C. S. Graves, A. R. Gaultieri, T. H. Seep, L. D. Smith, T. S. Williams.

Your committee submits the following final report as information and invites comments and criticisms thereon.

A. GROWTH OF PLASTICS

Plastics continue to excite curiosity, arouse skepticism and induce puzzlement because of their proliferation and slightly mysterious properties. To some they are the miracle materials of the future, to others they are cheap, shoddy substitutes that have no place in building. Both extremes are, in a sense, correct. Properly used, plastics have provided some outstanding answers to difficult problems. Improperly used, they have been sorry failures.

1. Definition

The term, “plastic” comes from a Greek word meaning “fit for molding,” and therefore can be rightly applied to rubber, metal, clay, cement, glass, putty or any substance capable of being molded or shaped. Through usage, however, it is now applied only to those synthetic, or “put-together” materials created and developed in the chemical laboratory. Some of these new creations are nearly as light as aluminum, almost as strong and durable as steel, thin as gauze, transparent as the best glass or varied in hue as the rainbow.

Strictly speaking, the construction industry is using both true plastics and the chemical elements which make them up. It uses both hard panels and sheets of plastic material, and it also uses liquids, such as epoxy resin. Officially, the American Society for Testing and Materials has defined plastics as, "A material that contains as an essential ingredient an organic substance of large molecular weight. It is solid in its finished state and at some stage of its manufacture can be shaped by flow."

Plastics are a large and varied group of materials consisting wholly or in part of combinations of carbon with oxygen, hydrogen and other ingredients. These arrangements are capable of being made into many forms through the application of heat and pressure.

What makes plastics so hard to define is that they start from so many different raw materials and end up in so many end materials. But basically there are two major divisions into which all plastics fall: Thermoplastics and thermosets.

Thermoplastics are much like candles in one respect: The synthetic resins, when exposed to sufficient heat, become soft only to harden again when the heat is removed. This process continues no matter how many times it is repeated and may require a very high temperature. Thermoplastics can be made up in sheets as solid as glass or with the consistency of leather or even rubber, and these can be remolded or reshaped many times by the application of heat. This category includes the high polymers, most of which carry the prefix "poly" and consist of giant molecules which in turn are made up of many tiny molecules in long, sub-microscopic strings that get tangled together to form a mass.

Thermosets can be compared to the whites of eggs. Heat initially applied to the resins permits forming of the material. Additional heat applied at a later date will char the material and destroy it. The thermosetting plastics do not rely on molecular strings but are constructed with chemical links that glue the big molecules together. The result is that these materials will not soften under heat at least up to temperatures that cause actual chemical decomposition. Thus thermosetting materials will retain their shapes and, when suitably reinforced, have ranges of stiffness similar to wood or concrete.

2. History

Probably because the manufacturers themselves keep pushing such terms as "modern," "new," and "revolutionary," many U. S. construction men are under the impression that plastics represent something brand new. Some present-day plastics have been in use for a very short time, but most of them are really refinements of older plastic materials that have been around for a very long time. The fact is, as early as 1823 French chemists discovered "polystyrene" and vinyl plastics. These were the first thermoplastics. Cellulose nitrates, better known as celluloids, were created in 1868. In 1909, the plastic industry took its greatest strides forward when Leo H. Baekeland discovered phenol-formaldehyde resins. These were the first man-made thermosetting plastics. They were identified under the trade name "Bakelite." Cellulose acetates were introduced in 1927. They advanced the art of thermoplastic molding.

Plastics have displayed one of the greatest growth surges in the industrial history of man. Since World War II, the multi-purpose, multiproperty material has affected the lives of everyone. Experts in government bureaus and the plastic industry think that by 1970 construction will be buying some 5 billion pounds compared to 2 billion pounds at present.

Despite the fantastic growth and the widespread publicity it has been accorded by all media, plastics remain an area of mystery and confusion to many builders, architects and engineers. Even those within the industry find themselves constantly challenged to keep abreast of the thousands of new formulations tested each year. The construction industry today finds itself with more than two dozen major plastics challenging more traditional materials. These plastics all differ from one another and to make matters more complicated, are offered under hundreds of generic and trade names. Plastics and materials made up of the same elements in other forms have come into wide use in the construction industry lately, and their use has been growing so fast that the construction industry is the largest single customer for plastics and similar materials.

Where the materials are being used is an excellent indication of the manner in which construction men have found them effective. Protective and decorative coatings, largely paints, sprayed-on waterproofing and similar materials accounted for 26 percent; flooring, tile and other products, 24 percent; adhesives, 9.5 percent; electrical equipment, lumineers, wire insulation, etc., 15.5 percent; tiles and fixtures, 5 percent; panels and illumination for decoration, room dividers and similar applications, 5.5 percent; piping, 5 percent; moisture barriers, 9.5 percent, of a 1.5-billion-pound total. These figures do not specifically mention insulation, which would be a large portion.

3. Construction Industry's New Approach to Plastics

In many ways, the most promising development in plastics is not in materials or methods but in a point of view or approach to building problems. Much of the effort to date has been on a sporadic individual item basis with vigorous research, development and promotion occurring in isolated areas depending upon the ability of the particular group involved. This has led to both success and failure but has not resulted in complete confidence in the reliability of plastics for buildings. It is now recognized by leaders in the industry that standards and specifications accompanied by reliability and reproductibility are essential if plastics are to progress into the volume and variety of applications in buildings which their properties seem to warrant. After several false starts in which different segments of the industry sometimes contradicted each other, an intra-industry group has emerged which is studying building codes and the proper inclusion of plastics in them, working steadily toward the goal of uniform, universal provisions for plastics.

Such provisions in turn demand standards and specifications acceptable to building designers and code enforcement officials. It is significant, therefore, that the ASTM has authorized its Plastic Committee to write standards and specifications not only for materials as such, but for end products. This step indeed was brought about by the building industry's requirements for such standards.

Plastic pipe has increased in annual dollar volume by approximately 12,000 percent during the past 15 years, and despite this present high level predictions are that it will increase another 500 percent over present volume in the coming decade. This dramatic increase is attributed as much to development of industry-wide voluntary standards as to the properties of the pipe. Intense committee work and testing by groups within the plastic industry and by independent evaluating organizations with the cooperation of pertinent government agencies has resulted in the offering of a series of standards, specifications and tests with seals of approval by respected independent agencies that in turn led to the development of model plumbing codes for plastic pipe and fittings. This continuing activity is not restricted to pipe for building applications, of course, but building uses were and are an important objective. The dramatic growth in volume of plastic pipe during the past decade attests to the efficacy of a well coordinated standard and testing program.

4. Impediments to Use of Plastics

a. The biggest problem with using plastics in construction is getting to know what they can do and how they can be used. A major problem is the fact that plastics are really man-produced, not a natural product. Building men have spent centuries learning how to use and adapt natural products, such as wood and stone. For many plastics, detailed information simply is not available. In a field as new as this one, it is not surprising that large segments of the building industry are uninformed about properties, uses, availability and limitations of plastics, nor is it surprising that a corresponding lack is to be found among plastic producers about the peculiarities and requirements of buildings.

b. Another obstacle standing in the way of wide-scale adoption of plastics in building is the uncertainty about their behavior upon long exposure to deteriorating environment, such as weather. There is no completely reliable short-term test to predict long-term behavior of plastic or other new materials when oxposed to weather. This constitutes a serious impediment because designers are reluctant to use new materials until their long-time history is established. Some plastics, of course, do have long histories and extensive data are being accumulated every year. Nevertheless, the problem remains for many new products and materials.

3. Another major impediment is fire. All plastics can be destroyed by hot-enough fires, some support their own combustion and some are self-extinguishing. Plastics, because of their nature, introduce new aspects into the problem of fire behavior, fire spread, fuel capacity and combustion products.

d. Still another problem is the method of attaching the material to other and different materials in a structure. Methods used include nailing, gluing, application of heat and imbedment (as in concrete). The most successful plastic applications in buildings are those in which complete systems or installation of components have been developed. It is not enough merely to have a good material; the material for building it into the finished structure must also be available. One reason for the widespread adoption of light-transmitting semi-structural and structural building sandwich panels is the availability of complete installation systems. The same is true for the bubble-shaped skylights. As more producers of plastic building components recognize this requirement, corresponding increases in the use of plastics may be expected.

All of this, then, boils down to the fact that architects and engineers should not use plastics indiscriminately, and certainly not interchangeably with traditional materials unless adequate data are available. They should be studied and the right products used in the right place with consideration for strength, chemical composition, fire resistance and other factors pertinent to a particular application.

B. VINYL IN BUILDING WORK

Polyvinyl chloride, leader of the plastics family, continues to add to its long list of building applications. The 35-year-old material boasts of a spectacular past, but its producers claim the best is ahead.

1. Flooring

The most familiar vinyl application is in hard-surface flooring so common to construction. While the first vinyl floor tiles were shown at the Chicago World's Fair in 1933, it wasn't until after World War II that the price of vinyl resins became attractive enough that any appreciable amounts of plastic found its way into resilient, smooth-surface flooring. Vinyl flooring today has captured the interest of public and building industry alike. It has not only made possible the production of many bright colors, but has also given manufacturers the opportunity to utilize transparent elements of decoration. A recent study shows that vinyl products now enjoy 48 percent of the total resilient and hard-surface flooring market as opposed to 17 percent six years ago. Vinyl flooring products are offered in four basic types: Flexible, which is sometimes referred to as homogeneous, with complete pattern penetration through the thickness; vinyl asbestos which is less flexible and lower in price; backed types which have vinyl laminated to various backing materials; and cork tile with clear vinyl surface.

2. Weather Stripping and Water Stop

Vinyl's enduring flexibility has not been confined to flooring but is also a chief factor for the popularity of the material as a weather-stripping and gasketing material. Vinyl is widely used for water-stop and expansion-joint applications in construction and more recently true elastomers—synthetic rubber that can be vulcanized—have come into considerable usage. Extruded elastomeric vinyl compounds have solved many problems in concrete construction, curtain walls and other applications. A pioneer in this development work claims that their water stops with specially designed ridges on both sides are 100 percent water tight and resist the effects of weathering and the growth of fungus. They function efficiently in temperature ranges from minus 58 to plus 170 F and have tensile strength not less than 1700 psi.

3. Flashing

Vinyl-alloy flashing can reduce roof maintenance costs. The material, by expanding and contracting, has the ability to accommodate constant building movement without rupturing or losing its resilience.

4. Vapor Barrier and Moisture Control

Vinyl film and sheet material, like polyethelene film, can be found on most construction sites. The lightweight, easy-to-handle film is used as a moisture barrier in floors, walls, roofs and shower stalls.

5. Doors and Windows

Manufacturers are producing vinyl-framed windows and doors fabricated from rigid vinyl, a material introduced in 1948 that features a "K" factor of only 0.1, which compares with 1400 for aluminum. This almost eliminates heat transfer through the sash. Rigid vinyl is frequently used with other materials in sliding doors and windows. The vinyl members offer integral color and smooth operation of members.

6. Pipe

Several types of plastic pipe are now available for water service. The most common are polyethelene and polyvinyl chloride. Flexible polyethelene represents about 75 percent of the total dollar market for plastic pipe. It has high impact strength and is low in cost. This type comes in coils for use under moderate pressures and low temperatures. Polyvinyl chloride pipe is very rigid and may be joined by threading or by solvent welding, has good dimensional stability, weathers well and will function through a wide range of temperatures.

The cost of installing plastic plumbing is estimated at 30 to 40 percent less than cast iron and 20 to 30 percent less than copper plumbing. The flexible material is estimated to have an even greater influence on cost when used in remodeling work.

7. Vinyl Coating and Wall Coverings

Plastic industry officials acclaim the current and future use of vinyl coating on steel, aluminum, concrete, wood, gypsum, etc. Such coatings add an abrasion- and weather-resistant surface, integral color, sound-deadening and thermal-insulating qualities. Many construction products on the market are being coated with vinyl in an effort to reduce job-site costs.

Steel corporations are now offering vinyl-coated steel for a wide range of applications, including siding, curtain-wall panels, duct work, etc. Sheets with a wide range of patterns and designs are available.

Vinyl coatings are applied by a continuous roller coating or spraying process before the final product is made. This is possible because the vinyl coatings will withstand punching, forming and bending stresses encountered during fabrication. Spray-gun techniques are generally used on finished structures, such as concrete or wood. Vinyl-coated gypsum wallboard is available in many designs. Some closely resemble wood and all can be applied with adhesive or predecorated nails.

Vinyl has gained great acceptance in the construction industry and its use is expected to increase in the months and years ahead.

C. EPOXIES AND SILICONES

Epoxy thermosetting resins have established themselves in construction because of their adhesion, hardness and resistance to chemicals and abrasion. They are polyethers resulting from a condensation process of epichlorhydrin and bisphenol. The liquid or solid material is then mixed with a certain proportion of catalyst causing a cross linking of molecules to take place. The end result is an infusible, insoluble thermosetting hard plastic.

Epoxy resin coatings may be brushed, sprayed, flow-coated, dipped, roller coated and troweled. They will adhere to ferrous metals, nonferrous metals, wood, plastic, glass, leather, rubber, paper, ceramics and wet or dry concrete.

Silicones have done much to repel water in all types of construction. First used in this country during the middle 1940's, the easy-to-apply silicones cause no change in the appearance of a structure. They are made from silicone chlorine. Unlike other water repellents, they allow masonry to "breathe" so that any moisture inside a building at the time of the application can later escape.

Silicones may be sprayed or brushed on concrete, stucco, brick, cinder block and stone, and will have a life expectancy of about 5 to 10 years. During this time, the treatment reduces darkening of masonry by water. Silicones also reduce the possibility of leaching of soluble salts which create efflorescence and spalling in brick walls.

D. FOAMED PLASTICS

Many plastics have been foamed, but the two families of plastics most used are polystyrene and urethane. While chemically different from each other, these plastics possess all of the properties required of a good thermal insulation. Foamed plastics first were developed about 15 years ago and sparked interest because of their unique properties. Densities can be made to range from 1 to 70 lb per cu ft. Cell size varies from microscopic to more than ½ in. in diameter.

Polystyrene, a thermoplastic, was the first to be foamed and has been used in roof, perimeter and wall insulation since 1948. Urethane, a thermoset, was introduced commercially about 6 years ago and possess a heat transmission rate of 0.15 at 75 F compared to polystyrene foam's 0.26, cork's 0.28 and glass fiber's 0.23.

While polystyrenes are less expensive for an equivalent insulation value, polyurethanes have superior heat-resistant qualities. Urethanes can be made in rigid, semi-rigid and flexible forms and applied in any of four ways: pouring and frothing, spraying, as slabs, and as premolded pieces. Polystyrenes can be used as slab stock and premolded pieces.

Slab stock has been the most common form used to date. Foam plastic boards are used for roof, wall and perimeter floor insulation. Special types of boards are offered, including pre-scored boards which can be quickly snapped to needed size. Slabs of foamed plastics are used for insulating core stock in sandwich panels. Industry has done much to stimulate the use of such panels in construction and gain their approval from local code authorities.

Spraying foam, possible only with urethane, is similar to spray painting. The foaming composition is sprayed on the surface where it quickly expands and hardens with excellent adhesion to most building materials. This method of application permits layers of foam of any desired thickness to be built up on a large surface area with no need for forms.

Premolded foam has few limitations as to shape or size. One of the most common forms is half-round in standard pipe diameters for rapid insulating of all types of piping applications.

Foam pouring and frothing eliminate the need for an adhesive when using the plastics between skins in such applications as curtain walls. When foam is applied by the pouring method, two liquid compounds are mixed together and the mixture is poured into the cavity to be filled. During the pouring process, the liquid components expand to 30 times their original volume, filling cracks and corners and forming a strong seamless core. Pouring is an ideal method for filling cracks, such as masonry wall cavities.

Frothing is a variation of the pouring method. The foam is blown out of the frothing equipment like squirting shaving cream from an aerosol can. The froth expands to only about four times its original volume, so little pressure is involved.

E. PLASTIC LAMINATES

Plastic laminates are almost all of one general type and consist of several layers. Protective sheets of melamine-formaldehyde-impregnated surface overlay a paper pattern sheet saturated with melamine and a phenolic core. Pressure and heat are used to laminate these into a homogeneous structure.

General-purpose and cigarette-proof types of high-pressure plastic laminates come in $\frac{1}{16}$-in thickness while forming stocks are available in 1/20-in thickness. All are resistant to heat up to 275 F, resist abrasion, cracking and crazing, and have good resistance to solvents, acids and alkalis. Laminates are now available in a wide array of unusual wood patterns, colors and designs. Most manufacturers offer several dozens, and some of the larger companies can incorporate an architect or builder-designed pattern in the long-lasting material.

Wood laminates can be cut, sawed, routed and fitted with conventional tools. The surface is impervious to ink, alcohol and other common staining agents, and is nonyellowing and needs no waxing.

F. REINFORCED PLASTICS

Acrylic and polyester resins are the primary plastics used today in producing reinforced materials, and fiber-glass mat is used as the reinforcing element in about 90 percent of today's production. Asbestos, sisal or cotton reinforcement also are used.

The reinforced-plastics industry has had to overcome many significant problems. Among these were exaggerated claims on color retention, material strength and applications. One of the first steps taken 10 years ago to regulate the industry was the formation of the Fiberglass Reinforced Panel Council, an affiliate of the Society of the Plastics Industry. Since then they have developed specifications, test procedures and performance adopted by ASTM and now used in federal specifications. In doing so, they have also established a stable and integrated growth in the reinforced plastics industry.

Reinforced panels can range in translucency from near transparent to opaque. Tints of green and blue allow as much as 90 percent transmission, while various intermediate yellows and blues have a light transmission of 45 to 65 percent.

Fiber-glass-reinforced panels are offered in dozens of colors, corrugations and configurations designed to fit with other building materials, such as siding, roofing, wood, aluminum and asbestos cement. Besides panels, the shatterproof material can be purchased in pre-cut glazing panes and flexible rolls.

Still another form of reinforced plastic panel is the laminated or sandwich type. Such panels now serve as translucent roofs, walls, windows, doors and room dividers.

Two main approaches have been used to create reinforced plastic sandwich panels: (1) A very small grid opening of such materials as honeycomb, folded and corrugated plastics, wood curls, etc., and (2) a fairly large grid with a structural grid member of aluminum or wood.

Much has been accomplished in perfecting the long-lasting qualities of reinforced plastic panels. Panels with 10- to 15-year guarantees are available in grades ranging from standard to premium.

G. FUTURE OF PLASTICS

Plastic-industry spokesmen tell us that the manufacture of plastic building materials will be a bigger industry by 1970 than the entire plastic industry today. There appears to be no limit to the development and materials that we can expect in the future. This enthusiasm is based upon the growing interest on the part of builders, architects and engineers to learn more about synthetics and how they can help to cut construction costs. The number of classes of plastics and the number of variations in each class are increasing. The number of processing and fabricating techniques that can be used also are increasing. Plastics have created and will continue to create new ways of building and will expand usefulness and life to conventional building materials. The years ahead will find plastics in head on competition with other basic materials.

H. THINGS TO WATCH FOR IN USE OF PLASTICS

Because the plastic industry is relatively new and lacks standard specifications written by independent organizations, the designer should exercise care in his choice of plastics and try to get specifications that define the performance wanted, or he should use the trade name rather than specifying "or equal." After specifications leave the designers' office for competitive bid, various sub-contractors, often without knowing the differences between various plastics and their performance, will be trying for substitutions. Unless specifications take this into account, poor results are bound to be encountered. When plastics are specified, take into account the companies which can furnish: (1) Personal technical representatives; (2) long-term service records; (3) long-term service data; (4) careful quality control; (5) technical design data; and (6) dependable complaint handling.

Designer's Checklist

1. Shock resistance (impact strength)
2. Cold flow (distortion under load)
3. Hardness
4. Tensile strength
5. Compressive strength
6. Abrasion resistance
7. Flexibility
8. Heat resistance
9. Dimensional change on aging (plasticizer loss and water absorption)
10. Thermal insulation
11. Specific gravity
12. Flammability
13. Appearance and color possibilities (transparency, brilliance, depth, translucency, surface smoothness and luster)
14. Color change on aging
15. Adhesion
16. Water resistance (water absorption)
17. Alkali resistance (household soap)
18. Acid resistance
19. Organic solvent resistance
20. Electrical properties

There has been one major problem in plastic construction in recent years: The attitude of labor unions toward their use. The problem has been one of jurisdiction in the craft-conscious construction industry where traditionally anything of wood becomes carpenters work and anything of stone is masons work. But plastics are none of these basic materials, or they may combine several of them. Plasterers have sometimes insisted on installing plastic walls simply because this has always been their work regardless of materials or methods. One answer has been assignment of work by the tools required. If it is cut with a saw it belongs to the carpenters, etc. A better answer may have to be education of the building trades as well as designers to the use of the new materials. Labor must be made aware of the fact that plastics do not necessarily reduce the amount of work, but often make it easier.

GLOSSARY OF TECHNICAL TERMS

Acrylic resins—A group of synthetic thermoplastic resins based on acrylic acid or related compounds.

Alkyd resins—Synthetic resins produced by reacting certain organic acids with alcohols related to glycerine. Used exclusively in paints and coating compositions.

Alpha cellulose—A variety of cellulose used in the manufacture of cellulose plastics and as a filler in urea-formaldehyde molding compounds.

Amino—Amino compounds are those containing the chemical group NH_2, such as urea.

Amorphous—The name given to solids which have no regularity of structure. Contrasted with crystalline.

Bakelite—Strictly a trade name for phenol-formaldehyde resins but often used indiscriminately for phenolic-resin products.

Benzene—A volatile inflammable liquid obtained from coal tar distillation. Not to be confused with benzine, a petroleum product having completely different chemical properties.

Breathing—A method of allowing gas to escape from a powder during a molding process, by releasing the pressure momentarily.

Butadiene—An unsaturated compound which when polymerized forms a basis of synthetic rubbers.

Casting—A method of forming by pouring liquid resin into an open mold and allowing it to harden without application of pressure.

Catalyst—A substance which causes a chemical reaction to take place without itself undergoing any permanent change.

Cellulose—The substance which forms the main constituent of the cell walls in plants.

Chain molecule—A linear molecule with a chain-like structure formed by the head-to-tail linking up of monomer molecules.

Chloroprene—The unsaturated monomer of the synthetic rubber Neoprene.

Cold flow—The slow distortion produced in a body when a force is applied for a long time.

Compreg—Wood which has been impregnated with synthetic resin and cured under heat and sufficient pressure to produce a large increase in density.

Compression Molding—Molding by filling the mold cavity with powder and closing the mold and applying pressure.

Condensation—A chemical reaction between dissimilar molecules which results in the elimination of water and the joining together of the parent molecules.

Co-polymer—A polymer obtained when two substances are mixed and polymerized together. The co-polymer contains units of both the monomers in the same molecule

Cracking—A process used in the treatment of petroleum by-products for breaking down large molecules into smaller ones.

Cross-linkage—A chemical linkage between adjacent polymer molecules, the formation of which results in an increase in hardness and rigidity, as for example in the vulcanization of rubber.

Crystalline substances—Substances whose molecules are arranged in a regular geometrical space lattice. They are characterized by extreme regularity of external form.

Curing—The chemical process of converting a thermosetting resin from a fusible condition to an infusible, insoluble condition, either by the application of heat or under the influence of a catalyst.

D.B.P.—Dibutyl phthalate—a plasticizer.

Dielectric strength—The resistance of a material to very high applied voltages.

Dibutyl phthalate—A common plasticizer, sometimes called D.B.P.

Elastomer—A polymer with rubber-like properties.

Ethylene—The unsaturated hydrocarbon, C_2H_4.

Extrusion—A process for producing rods, tubes and regular sections by forcing plastic material through an appropriately shaped die.

Fibre—A substance formed from well-oriented polymer chains, characterized by great flexibility and high tensile strength.

Filler—Any material added to a synthetic resin or plastic to improve its physical properties.

Formaldehyde—A gas having the formula H.CHO and used as a 40 percent solution in water (called formalin) in the manufacture of phenolic and amino resins. Also used as a preservative and disinfectant.

Formalin—A 40 percent solution in water of the gas formaldehyde.

Gel—A semi-rigid, jelly-like substance.

Hardener—A catalyst. Usually applied to one used with synthetic resin adhesives.

Hexamine—A white crystalline solid formed from formaldehyde and ammonia, and used in the manufacture of two-stage phenolic molding powders.

Hydrocarbon—A substance composed solely of hydrogen and carbon.

Impreg—Wood impregnated with resin and cured under heat and pressure insufficient to produce any compression of the wood or increase in density.

Lacquer—A solution of a resin in a volatile solvent which forms a film by the purely physical process of evaporation of the volatile solvent.

Laminate—A sheet or other section formed by bonding together a number of thin sheets of material impregnated or coated with synthetic resin.

Lignin—A naturally occurring resinous material found in wood and other cellulosic substances.

Melamine—An amine which forms with formaldehyde resins similar to those formed by urea.

Molecular weight—The weight of a molecule expressed on a scale in which the weight of one atom of hydrogen is taken as unity.

Molecule—The ultimate structural unit of a compound.

Monomer—A simple unsaturated molecule which is capable of uniting with similar molecules and forming a polymer.

Novolak—A permanently fusible and soluble phenol formaldehyde resin formed when the ratio of phenol to formaldehyde in the reaction mixture exceeds a certain limit.

Nylon—The generic name for a group of condensation polymers formed from polybasic acids and polyacidic amines.

Orientation—A molecular arrangement with all the molecules pointing in one direction.

Pellets—Small preforms of regular shape used to facilitate the loading of molding presses.

P.F. resin—Phenol-formaldehyde resin.

Phenol—The chemical substances C_6H_5OH sometimes called carbolic acid, derived from coal tar, and forming one of the basic ingredients of phenolic resins. The name is sometimes used generically to cover all the substances chemically allied to phenol, e.g., cresols, xylenols, etc.

Phenolic resin—A resin formed by reacting formaldehyde with phenol, cresols or similar chemical substances.

Plasticity—The property possessed by some substances of flowing when a pressure in excess of a critical value known as the yield stress is applied. Plastic materials will resist lower stresses and hence are distinguished from liquids.

Plasticizer—A solid or liquid used to increase the plasticity or improve the flow properties of a resin or plastic material.

Poly—A prefix indicating a polymer, e.g., polystyrene, polymerized styrene.

Polyamide—Long chain amino compounds of the nylon type.

Polymer—A substance whose molecules are very large and built up from simpler monomer units.

Polymerization—The process of building up large molecules by the reaction of unsaturated small molecules.

Proteins—Naturally occurring high polymers, including certain foodstuffs, such as casein, egg albumen and gelatine. Also includes substances like hair, silk, wool, leather and horn.

Radical—A group of atoms which takes part in chemical reactions without changing its identity and acts very much like a single atom.

Rayon—Synthetic fibres based on cellulose or its derivatives.

Resin—A solid or semi-solid substance of natural or synthetic origin characterized by brittleness and glass-like fracture.

Saturated compounds—Compounds in which all the chemical valency links between carbon atoms are single bonds.

Secondary bonds—Forces other than primary chemical valance bonds between molecules.

Side group—A chemical group attached to the side of a polymer chain.

Styrene—An unsaturated compound made synthetically from benzene and ethylene and having the formula $C_6H_5CH:CH_2$.

Synthetic—A substance made by chemically reacting simpler substances.

Thermoplastic resin—A resin which softens when heated and becomes hard again on cooling. The softening by heating can be repeated indefinitely.

Thermosetting resin—A resin which softens on an initial application of heat but which quickly becomes hard and infusible on continued application of heat.

U.F. resin—Urea-formaldehyde resin.

Unsaturated compounds—Compounds in which double and/or triple valency links between carbon atoms are present.

Urea—A white crystalline solid prepared synthetically from ammonia and carbon dioxide and used in the manufacture of urea-formaldehyde resins.

Valency—A measure of the combining power of an atom. The number of valencies possessed by an atom determines the number of other atoms with which it will chemically combine.

Vinyl compounds—Compounds or polymers containing the vinyl group $CH_2{=}CH{-}$ and including such substances as polyvinyl chloride, polyvinyl acetate, styrene, etc.

Vulcanization—The process of hardening rubber or synthetic rubber by reacting with sulfur-containing compounds.

BIBLIOGRAPHY

1. Deitz, Albert G. H. "Plastics in Architecture: Taking Stock," *Architectural and Engineering News,* June 1963.
2. Mactaggart, E. F. and H. H. Chambers. *Plastics and Building.* New York: Philosophical Library, 1955.
3. *Modern Plastics Encyclopedia,* 1964. Vol. 41, No. 1A.
4. Morgan, Phillip. *Progress in Plastics.* New York: The Macmillan Co., 1960.
5. "The Spectacular Growth of Plastics," *Building Products,* April, 1962.

Report on Assignment 8

Infra-Red Heating

Collaborating with Committee 18

D. A. Bessey (chairman, subcommittee), E. P. Bohn, J. S. Cooper, V. E. Elshoff, C. S. Graves, A. R. Gaultieri, J. W. Gwyn, H. R. Helker, H. J. Lieser, R. E. Lilliston, C. R. Madeley, L. J. Nichols, C. L. Robinson, R. A. Ullery.

This final report, presented as information, deals primarily with various types of infra-red heating installations. Previous reports published in Vol. 60 and Vol. 62 of the Proceedings covered, respectively, the principles of infra-red heating and the economics of infra-red heating for buildings.

Installations of infra-red equipment for building heating, spot heating within buildings and many other applications have been made throughout the railroad industry. Many such installations have proven to be very successful, providing a practical and economical means of heating structures or isolated work areas.

Infra-red heating is being used for general building heating, perimeter heating of buildings, and spot heating of work areas, equipment or objects. Other applications include coal and ore-car thawing, switch heating, canopy or trainshed heating, heating work-bench areas in various types of unheated shop buildings, and so forth.

Design criteria are not readily available from engineering reference books, and only a limited amount of calculation procedure is available from manufacturers and distributors of infra-red heating equipment. Because of the specialized utilization of infra-red heating, it would be difficult to set up standardized design procedures.

Basic heating design criteria were undoubtedly utilized for the initial installations of infra-red heating equipment. Trial and error were very possibly put to good use also. This past experience will help in perfecting future installations.

Because of the many indeterminents involved in planning such installations, standard solutions by equations are not available, as mentioned previously. This holds true even for such a simple application as providing a single infra-red heating unit over a work bench area. The amount of heat or the degree of comfort required for the particular task to be performed, the prevailing temperatures of the area, wind condition, etc., are all factors to be considered. For a single area, an educated guess may suffice, and if the installation is ultimately 100 or 200 percent over-designed, the extravagance may amount to only a few cents. But if it is desired to heat many similar work bench areas in a large shop or industrial plant, a more precise method of design is an economic necessity.

The various types of installations are generally designed by methods set up by the manufacturer or distributor. These methods, in part, are based on results obtained from experimental installations and applications of heating equipment installed by private industry and other users.

To provide additional design information, your committee presents below details of specific infra-red heating installations made by various railroads.

Diesel Locomotive Heating: Six 48,000-Btu natural-gas infra-red heaters mounted 14 ft above the floor and located on both sides of diesel storage tracks. The storage tracks are located in one end of a large shop building which is otherwise unheated. The heaters are turned on only when the locomotives are stored in the building. The six heating units provide sufficient heat to prevent freezing of cooling water and maintain an oil temperature high enough to permit starting the locomotive after a 12 to 24 hr shutdown of the diesel engines, during sub-zero weather.

Shop Space Heating: Eighteen 48,000-Btu gas infra-red heaters in a 90 by 124 ft shop building for general space heating. These are mounted 14 ft above the floor. The majority of the units are mounted around the perimeter of the building and are controlled by two room thermostats. With only 13 of the 18 units in operation, a temperature of 60 F can be maintained in the building when the outside temperature is —10 F.

Roundhouse Heating: Infra-red heaters in 7 stalls of a 16-stall roundhouse used for active diesel storage. The roundhouse is otherwise unheated. Five 48,000-Btu gas infra-red heaters are mounted between each stall at a height of 15 ft. Each row of heaters is controlled by a room thermostat. The heaters are not put in operation unless the adjacent stall is occupied by a locomotive.

Rail-Trucking Terminal Heating: Thirty-nine 44,000-Btu natural-gas infra-red heaters to provide general space heating for a garage area, loading dock area and an enclosed truck-trailer area, plus two 300,000-Btu gas-fired make-up air heaters in the garage area. The units are mounted 16 ft high, with general distribution in the garage area and perimeter heating in the loading dock and truck-trailer areas. The heating system maintains an average temperature of 60 F in the garage, 45 F in the loading dock area and 35 F in the truck-trailer area when the outside temperature drops as low as —45 F.

Spot-Car Repair Shop Heating: Four 48,000-Btu gas-fired infra-red heaters at each of the two general work areas on each track of a four-track shop. Each bank of four heaters is controlled by a timer switch so that the heaters are put in operation only when the work area is occupied. The building was constructed with open ends and side walls, and the heating system was not too satisfactory at first. With the later closing in of the side walls and the installation of a rolling steel door at one end of the house, the effect of the heaters was much improved.

Heating at Shop Machine: One 50,000-Btu gas infra-red heater over a saw in the carpenter shop. The installation maintained comfortable working conditions at the work area when the average temperature throughout the otherwise unheated shop was sub-zero.

Stock Car Cleaning Track Heating: An installation of an underground gas service line with regulators and shut-off valves located at 125-ft centers along a stock car cleaning track for connecting 144,000-Btu portable infra-red heaters. The heaters are placed in the stock cars for thawing frozen sand and manure.

Coach Repair Shop Heating: One-hundred 48,000-Btu gas infra-red heaters in a four-track, 76- by 480-ft shop building. The units are mounted 15 ft high and located along the side walls and through the center of the building at approximately 16 ft centers. The operation of the heating units is controlled by nine room thermostats.

Report of Committee 3—Ties and Wood Preservation

W. E. Fuhr, *Chairman*

K. C. Edscorn,
Vice Chairman

C. S. Burt
H. F. Kanute
W. W. Barger
L. C. Collister
W. F. Arksey
P. D. Brentlinger
A. B. Baker
R. S. Belcher (E)
G. W. Brenton
R. G. Brohaugh
W. Buehler (E)
C. A. Burdell
C. M. Burpee
R. E. Case
E. M. Cummings
D. L. Davies
C. E. DeGeer
T. J. Delaney
R. F. Dreitzler
H. R. Duncan
M. S. Edwards
John Fox
F. J. Fudge
J. K. Gloster
H. M. Harlow
F. F. Hornig
M. S. Hudson
R. P. Hughes (E)
F. S. Hunter
W. R. Jacobson
H. W. Jensen
L. W. Kistler (E)
M. A. Lane
T. F. Maloney
H. C. Martin
J. J. McManus
W. G. Merritt
C. S. Morton
T. H. Patrick
C. A. Peebles
R. B. Radkey
H. E. Richardson
H. S. Ross
N. A. Salzano
J. T. Slocomb
O. W. Smith
R. B. Smith
E. F. Snyder
L. S. Strohl
G. A. Williams
J. L. Williams
H. K. Wyant
R. G. Zietlow
Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 3.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Brief progress statement, presented as information .... page 226

2. Cross and switch ties:

   (a) Keep up to date specifications for cross and switch ties.
   No changes in specifications recommended at this time.

   (b) Extent of adherence to specifications for cross and switch ties as observed on field inspections.

   Progress report, presented as information .... page 227

   (c) Possible revision of cross tie design and/or spacing, collaborating with Committee 5.

   Progress report, presented as information .... page 227

   (d) Feasibility and economics of reusing recovered ties, with or without additional treatment, collaborating with Committee 22 and Purchases and Stores Division, AAR.
   No additional information has been developed on this subject since publication of the reports in Bulletin 575, December 1962, and Bulletin 582, December 1963.

(e) Feasibility and methods of predicting years of service life remaining in individual cross ties.

Since publication of the last report on this subject in Bulletin 582, December 1963, no additional information has been developed.

3. Wood Preservatives:

(a) Keep up to date specifications for preservatives.

No necessary changes have come to the attention of the committee during the past year.

(b) New preservatives.

No new preservatives with sufficient usage to warrant study have come to the attention of the committee during the past year.

4. Preservative treatment of forest products.

Brief progress statement, presented as information .... page 229

5. Service records of forest products.

(a) Annual tie renewal statistics as furnished by the Bureau of Railway Economics, AAR.

The annual statistics compiled by the Bureau of Railway Economics, AAR, providing information on cross tie renewals and cost data for 1963 for the Class I Roads of the United States and the large Canadian roads were published in Bulletin 586, June–July, 1964, page 926.

(b) Marine organisms.

Progress is reported in the collection of data under this assignment.

(c) Service test records of forest products used in railroad construction and maintenance.

Progress report, presented as information .... page 229

6. Collaborate with AAR Research Department and other organizations in research and other matters of mutual interest.

No report.

THE COMMITTEE ON TIES AND WOOD PRESERVATION,
W. E. FUHR, *Chairman.*

AREA Bulletin 589, December 1964.

Report on Assignment 1

Revision of Manual

C. S. Burt (chairman, subcommittee), K. C. Edscorn, W. E. Fuhr, R. P. Hughes, H. F. Kanute, M. A. Lane, C. A. Peebles, N. A. Salzano, O. W. Smith, R. B. Smith, E. F. Snyder, L. S. Strohl, J. L. Williams.

This committee, having jurisdiction over two chapters of the Manual—Chapter 3—Ties, and Chapter 17—Wood Preservation—has continued its study of methods and procedures in use, with the view to keeping the material in these chapters abreast of best practice.

In its study of the chapters themselves, the committee has found some data that needs correcting. But the changes are largely editorial in nature and can be deferred until next year, when a rather general revision of the two chapters is anticipated.

Report on Assignment 2

Cross and Switch Ties

H. F. Kanute (chairman, subcommittee), P. D. Brentlinger, E. M. Cummings, J. Fox, F. J. Fudge, J. K. Gloster, F. F. Hornig, F. S. Hunter, W. R. Jacobson, H. W. Jensen, M. A. Lane, T. F. Maloney, H. S. Ross, N. A. Salzano, J. T. Slocomb.

EXTENT OF ADHERENCE TO SPECIFICATIONS FOR CROSS AND SWITCH TIES AS OBSERVED ON FIELD INSPECTION

During the month of June 1964, Committee 3 inspected cross and switch ties in one tie yard in Illinois. The ties observed were of red or white oak, and of sizes 2, 3, 4 and 5, all 8 ft 6 in long. All ties were of excellent quality. The green ties were neatly stacked for seasoning in accordance with AREA Manual recommendations. Sizes 2 and 3 were stacked together, as were sizes 4 and 5.

All ties were well marked as to size and each stack was marked as to the date that seasoning began. "S" irons had been applied selectively by the producer. However, just prior to treatment all switch ties were doweled, and all cross ties showing splits were doweled with two 3-fluted dowels in each end without regard as to whether "S" irons originally had been placed in individual green ties. The ties were acceptable as to size classification under AREA specifications.

The yard was clean and well drained.

POSSIBLE REVISION OF CROSS TIE DESIGN AND/OR SPACING (STANDARDIZATION OF CROSS TIES), COLLABORATING WITH COMMITTEE 5

The following report is based on the replies to a questionnaire received from 24 railroads and the cross tie treating industry as represented on Committees 3 and 5. The railroads represent all sections of the United States and Canada.

Size of Ties

Nearly all railroads use sizes 4 and 5 ties for principal and secondary main lines. A few use size 3 ties for secondary mains. Sizes 2 and 3 ties are used for branch lines, yard tracks and industry tracks. On a few railroads, 1 to 5 percent of the total ties purchased were of size 1 for use in light industry or yard tracks.

Of the 24 reporting railroads about 40 percent stated that two sizes of ties would be sufficient for their use. However, there is a variation in the sizes desired: some prefer sizes 3 and 5, others, sizes 3 and 4. The roads that could get along with only two sizes could not see any resulting reduction in cost. In some cases where sizes 3 and 5 ties are purchased but a small percentage of size 2 ties mixed with the size 3, and size 4 ties mixed with the size 5, is acceptable, a reduction in cost for the smaller sizes is allowed. This would not be realized if only two sizes were adopted.

As a matter of information, the Federal specification for ties, revised as of July 2, 1964, includes eight sizes of cross ties: 5 by 5 in, 6 by 6 in, 6 by 7 in, 6 by 8 in, 7 by 7 in, 7 by 8 in, 7 by 9 in and 7 by 10 in.

Anti-Splitting Devices

The practice of selective doweling after seasoning is being followed by 13 of the railroads reporting. One railroad is doweling all ties, another is doweling all ties except sizes 1 and 2 in which sharon irons are applied. Three railroads use "C" or "S" irons in all ties. Three railroads apply "C" or "S" irons selectively. Two railroads have recently changed from applying "C" or "S" irons in all ties to selective doweling, for economic reasons and more effective planning in their use of anti-splitting devices. Three railroads that are vapor-drying ties are not using any anti-splitting devices, as less than 5 percent of the ties after drying show any cracks needing control.

Adzing and Boring

Fifty percent of the railroads reporting stated that they are not now adzing ties; three reporting roads see no need to continue to adze sawed ties, but they are still adzing ties because their adzing and boring machine perform both operations simultaneously. Four railroads do no adzing or boring of any ties. Three railroads are boring for better penetration of preservative and drainage underneath the tie plate without regard to location of spikes. The other 17 reporting railroads bore 4 to 8 holes per tie for spikes. However, the railroads that bore for spikes report that only 50 to 90 percent of the spikes are actually driven in the bored holes.

Previous tests have shown that spikes driven into bored holes have considerably more holding power than spikes driven into ties not having prebored holes.

Treatment

About 60 percent of the railroads replying to the questionnaire use creosote-coal tar solutions in proportions of 50/50, 60/40, 70/30 or 80/20, with retention varying from 6 to 9 lb per cu ft; 30 percent use a 50/50 creosote-petroleum solution and 10 percent use a 30/70 creosote-petroleum solution, with retention varying from 6 to 12 lb per cu ft. The railroads using creosote-petroleum solutions have standardized on proportion and retention to a greater extent than those using creosote-coal tar; those using the 30/70 creosote-petroleum solution are requiring the higher retention, thus getting about the same amount of creosote into the tie as those using the 50/50 solutions with the lower retention.

Coal tar is a by-product and no specifications have been written for it. Thus the consistency of the coal tar purchased from various producers determines the amount of creosote necessary to be added to thin the solution in order to secure proper penetration. Species also have some bearing on the solution and retention needed. Chemical analysis shows that creosote contains more than 150 different compounds. Creosote oils having a high percentage of low-boiling compounds disappear from the wood more rapidly than creosote oils having a high percentage of high-boiling compounds. Referring to US Forest Circular 188, page 646, we find that oils extracted from old timbers contain a large percentage of high-boiling compounds.

Summary

It appears that some further standardization as to size could be worked out on the basis of the uses made of ties by the railroads, but it is doubtful if further revision of standards as to size would be economical. The railroads recognize that to fully utilize the timber available for ties, several sizes are necessary.

There is a trend towards the selective use of anti-splitting devices. However, additional study is necessary to determine the best plan to follow, that is, whether to use anti-splitting devices in all ties, or to use them selectively, and to determine the best and most economical type of anti-splitting device to use.

The cost of adzing and boring is 10 to 15 cents per tie. The elimination of the adzing operations for sawed ties would make very little difference in this cost, since adzing and boring are done in one operation and it is felt by most railroads that boring holes for spikes should be continued. Further study on the value of adzing and boring for spikes or for drainage and penetration of preservative is necessary before recommending greater standardization in this regard.

Because of the wide variation in species, climate and availability of coal tar and petroleum in different parts of the United States, it is difficult to standardize treatment solutions and retentions.

In Canada, the two major railroads use tie sizes 2, 3 and 5, 8 ft long, make their own application of anti-splitting devices, treat ties with a 50/50 creosote-petroleum solution with a retention of 7 lb per cu ft, do not adze ties and prebore 4 to 6 holes for spikes. This greater standardization is possible because these roads have the same climatic conditions, and the same species and treatment products are available to both at the most economic prices.

No railroad or tie treating company reporting feels that any reduction in cost of ties could be made by further standardization. One tie treating company stated that railroads could do more to keep tie prices from rising by establishing a constant buying level throughout the year than by any other one thing they could do.

This is a progress report submitted as information.

Report on Assignment 4

Preservative Treatment of Forest Products

L. C. Collister (chairman, subcommittee), G. W. Brenton, C. A. Burdell, R. E. Case, D. L. Davies, R. F. Dreitzler, K. C. Edscorn, W. E. Fuhr, M. S. Hudson, F. S. Hunter, J. J. McManus, C. S. Morton, T. H. Patrick, R. B. Smith, R. G. Zietlow.

During our June meeting, the committee observed a test installation of incised and non-incised oak ties which had been in service 29 years under heavy yard traffic. The advantages and disadvantages of incising are under study by the committee.

The committee also observed vapor-dried ties in main line tracks. These are too recently installed, however, to permit drawing any conclusions as to their behavior in service.

At the convention in March, the committee will make a recommendation regarding the assay method of analysis of retention of preservative in round timbers.

Report on Assignment 5

Service Records of Forest Products

W. F. Arksey (chairman, subcommittee), A. B. Baker, C. M. Burpee, C. E. DeGeer, K. C. Edscorn, M. S. Edwards, F. J. Fudge, W. E. Fuhr, H. M. Harlow, R. P. Hughes, C. A. Peebles, R. B. Radkey, J. T. Slocomb, E. F. Snyder, L. S. Strohl, J. L. Williams.

SERVICE TEST RECORDS OF FOREST PRODUCTS USED IN RAILWAY CONSTRUCTION AND MAINTENANCE

Your committee cooperated with the AAR Research Center staff in making an inspection on February 3 and 4, 1964, of specimens after 76 months of exposure in the Austin Cary Memorial Forest, Gainesville, Fla., in an investigation to determine the most effective preservative and amount of retention to reduce decay and termite attack in oak, pine and fir timber. The AAR Research Center has published the results of the test at the end of the 76-month period in Report No. ER–46, which was furnished to chief engineers of Member Roads in June 1964. Additional copies may be obtained from the AAR Research Center, Chicago.

The report summarizes the results of the test as follows:

1. Specimens treated with coal tar creosote show less decay and termite attack than specimens treated with other preservatives.
2. Chromated zinc chloride and tanalith are affording less protection against decay and termite attack than other preservatives. However, the rate of decay and termite attack is reduced considerably by treating specimens with even the lower retentions of chromated zinc chloride or tanalith.
3. In general, the fir specimens treated with most of the preservatives, are subject to less decay and termite attack than the oak and pine specimens.

After 24 months of exposure, untreated specimens installed in February 1962 yield the following results: One of the oak, three of the fir and ten of the pine specimens had completely failed, and again there is indication that oak specimens are more subject to decay than termite attack. It appears from the average index ratings that most of the specimens will fail within the next few months.

This report is presented as information.

Report of Committee 11—Engineering and Valuation Records

M. C. Wolf, *Chairman*

H. R. Williams,
Vice Chairman

R. S. Shaw, Jr.,
Secretary

J. L. Manthey
J. Bert Byars
W. A. Krauska
W. J. Pease

C. R. Dolan
R. D. Igou
C. F. Olson
F. A. Roberts
R. B. Aldridge
F. B. Baldwin (E)
G. R. Bergquist
B. A. Bertenshaw (E)
P. E. Bierman
H. C. Boley
C. E. Bynane
J. R. Clayton
P. L. Conway, Jr.
B. J. Cook
C. J. Cosner
R. L. Ealy
R. F. Garner
W. S. Gates, Jr.
M. M. Gerber
E. W. Gibson
L. F. Grabowski
W. M. Hager
C. C. Haire (E)
Nelson Hammond
J. E. Hebbron
M. J. Hebert
J. J. Hoolahan
J. A. L. Houston
L. W. Howard

W. C. Kanan
W. H. Kiehl
M. W. Krug
R. A. Johnson
R. A. Lariviere
J. W. Laurent
C. E. Lex, Jr.
J. G. Maher
M. F. McCorcle
F. J. Merscher
C. W. Meyer
B. H. Moore
D. J. Murray
D. L. Murray
M. L. Myers
B. F. Nauert
D. E. Pergrin
C. H. Rapp
C. S. Robey
J. H. Robinson
E. J. Rockefeller
J. W. Rowland
H. B. Sampson
R. L. Samuell
J. E. Stein
J. B. Styles
J. R. Traylor
Louis Wolf (E)
Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 11.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No report at this time.

2. Bibliography on subjects pertaining to engineering and valuation records.

   Progress report, submitted as information .... page 232

3. Office and drafting practices.

   The study of microfilming of engineering records and reports continues, but no further report is presented.

5. Use of statistics and data processing in railway engineering.

   Progress report, submitted as information .... page 234

6. Valuation and depreciation.

   (a) Current developments in connection with regulatory bodies and courts.
   Progress report, presented as information .... page 240

(b) ICC valuation orders and reports.
No report. Some information on this subject is included in the report on assignment 6 (a).

(c) Development of depreciation data.
No report.

7. Revisions and interpretations of ICC accounting classifications.
Progress report, submitted as information .... page 242

8. Instructions for making engineer field checks and their application to completion reports.
Further report held in abeyance pending revision of ICC requirements.

9. Simplification of annual reports on Form 588 to the Interstate Commerce Commission, and underlying completion reports.
Further report held in abeyance pending revision of ICC requirements.

THE COMMITTEE ON VALUATION RECORDS AND ACCOUNTS,
M. C. WOLF, *Chairman.*

AREA Bulletin 589, December 1964.

Report on Assignment 2

Bibliography on Subjects Pertaining to Engineering and Valuation Records

J. B. Byars (chairman, subcommittee), P. L. Conway, Jr., C. R. Dolan, R. F. Garner, J. A. Houston, L. W. Howard, R. D. Igou, C. F. Olson, W. J. Pease, E. J. Rockefeller, H. R. Williams, M. C. Wolf.

Accounting

Journal of Accountancy, Jan. 1964. "Property Valuation Problems and the Accountant."

Purchases and sales may freeze much of a company's investment into non-depreciable status unless accountants allocate values to the intangible assets.

Railway Age, June 15, 1964, pages 35–36. "Computers and the Paperwork Explosion."

A discussion of the relationship of modern computers to accounting and financial practices.

Modern Railroads, July 1964, page 157. "Machines Broaden Accounting Services."

A summary of uses to which the Northern Pacific Railway puts its data processing equipment, including payroll, inventory, car accounting, freight and passenger revenue accounting and other statistics.

Working On The Tracks, published by AAR, May 1, 1956.
Working In The Shops, published by AAR, April 1, 1958.
Conducting Transportation, published by AAR, August 15, 1960.

Attention is again called to the above three books which are helpful not only to experienced railroad accounting officers and clerks but especially to new railroad employees in many departments who need some knowledge of railroad accounting.

Budgeting

Business Week, May 30, 1964, pages 76–78. "Business Budgets—to each his own."

A discussion of planning and control problems as studied by members of the Budget Executives Institute in their Philadelphia meeting.

Depreciation

Client's Service Bulletin, Vol. 40, No. 5, Oct. 1963, page 3, "Engineering Approach to Remaining Lives."

The engineer is not consulted on depreciation questions as often as other professionals and officials who are less qualified.

Office Procedure

Railway Age, Dec. 2, 1963, pages 15–16. "System-wide data processing on tap for ACL."

Atlantic Coast Line's new communications system will do just about everything from locating a car to accounting.

Business Week, Dec. 28, 1963, pages 82–83. "Electrons That Add."

Anita, a desk-top electronic computer, comes over from England. It's faster and does things a mechanical calculator can't do. It has instantaneous addition and subtraction with no "add" button to punch for each entry. The division and multiplication operations are extremely fast with no accompanying noise and are complete with automatic decimal pointing.

Business Week, Feb. 29, 1964, pages 70–90. "New tool, new world."

A special report on the progress of electronic data processing and the uses of computers.

Business Week, April 11, 1964, pages 67–70. "IBM's new System No. 360 data equipment."

A completely new, modernized, faster, larger and more complete data processing system, featuring microelectric integrated circuits.

Progressive Railroading, May–June 1964, pages 21–26. "Railway Purchasing Progress."

How the Missouri Pacific Railroad uses computers to help control inventory and aid in buying.

Modern Railroads, July 1964, page 190. "Computers Become Railroad Tools."

Editorial comment on "value analysis" and "computer analysis" which help solve railroad problems.

Taxes

Modern Railroads, Dec. 1963, pages 40–41. "Railroad Stake in Tax Legislation."

A discussion of the possible benefits for railroads from the proposed tax reform legislation and effects of recently passed legislation on the railroad industry.

Railway Age, Dec. 9, 1963, pages 21–28. "Tax Outrage."

A thorough discussion of railroad tax problems and the discriminatory assessment of railroad property at a higher value than non-railroad property with a conclusion as to possible remedies to the problem.

Modern Railroads, March 1964, page 30. "A $72 Million Tax Break."

An analysis of the probable benefit to railroads resulting from the recent $11.6 billion tax reduction.

Valuation

The Federal Valuation Of The Railroads In The United States, by B. H. Moore, Valuation Assistant and Accountant, Finance, Accounting, Taxation and Valuation Department, Association of American Railroads.

This booklet, reprinted from AREA Bulletin 503, Sept.–Oct. 1952, is an outstanding contribution to valuation literature. It is valuable not only to those engaged in valuation work, but also to those involved in rate cases, taxation, etc. It may be used as a history of valuation, a reference book and as an authoritative statement of the procedures of the ICC's Bureau of Accounts.

Report on Assignment 5

Use of Statistics and Data Processing in Railway Engineering

Howard R. Williams (co-chairman subcommittee on Engineering phases), William J. Pease (co-chairman subcommittee on Accounting phases), R. B. Aldridge, P. E. Bierman, H. C. Boley, J. Bert Byars, P. L. Conway, Jr., B. J. Cook, C. R. Dolan, R. L. Ealy, R. F. Garner, W. S. Gates, Jr., L. F. Grabowski, W. M. Hager, M. J. Hebert, J. A. Houston, R. D. Igou, W. H. Kiehl, W. A. Krauska, C. E. Lex, B. F. Nauert, C. F. Olson, D. E. Pergrin, F. A. Roberts, E. J. Rockefeller, H. B. Sampson, J. E. Stein, M. C. Wolf.

This is a progress report, presented as information.

Previously your committee had canvassed its membership to establish the degree to which electronic data processing was being applied in those fields related to our assignment. Current activity is directed towards enlarging our concept of computer theory and uses to stabilize our ideas and develop (a) information that can be prepared for machine processing, (b) methods of processing the information, (c) study of applications underway or completed, and (b) theory applicable for a recommended procedure.

DATA PROCESSING OF CONSTRUCTION REPORTS—ENGINEERING PHASES

Purpose of Study

The generation of engineering and accounting data for construction projects is being considered. Specifically we have included those phases, basically engineering, that relate to the acquisition and classification of source data and processing of such information for the establishment and perpetuation of engineering and property records for real property. The study being in the initial stages of investigation and development, it is not intended as being representative of a recommended procedure for mechanization but rather an outline of the methods we feel are appropriate for a study of the problem.

Engineering and Property Records

Familiarity with and the need for construction reports and property records is recognized generally by all railroad engineers and railroad executives. However, the corporate procedures involved to produce and perpetuate these records is not so generally understood.

As property is acquired, records are created, after which these property records are maintained and updated with each significant change in the item's history. Basic requirements dictate the necessity of providing a description as to the nature, extent and location of the change as well as cost. Records must be accurate, readily available and current to serve a multitude of corporate needs.

Existing Manual Procedures

Property record data for every kind of real property, from land to buildings and pavement to utility systems, currently are transmitted from the field to the general office, in the main, using manual procedures. Such familiar reports and records as the following are used:

For submission of engineering plans and reports:

(a) Engineer's detailed estimate of cost and request for construction project authority.
(b) Authority for expenditure (AFE).
(c) Engineering plans and specifications.
(d) "As constructed" or "as built" prints.
(e) Engineer's closeout reports as to construction details.
(f) Miscellaneous other reports.

For submission of accounting cost data for the project:

(a) Labor documents.
(b) Material documents.
(c) Statement of expenditures for a construction project.
(d) Miscellaneous other reports.
(e) Financial closeout for a project.

Property Accounting Defined

Business and industry may use the term *plant and equipment accounting,* which is defined as a financial history of money transactions that concerns buildings, land, machinery, equipment, structures and vehicles—all of them a part of the business enterprise, but none of them the marketable products or services of that enterprise. In such circles the property is usually called a capital asset or fixed asset. In government, particularly with the military, the term *real property* is used, defined as the fixed-capital assets accountable under a precise and comprehensive system of accountability, including but not limited to land and all interest therein, buildings, structures, utility systems and permanently attached or installed appurtenances thereto. For the purpose of this report *property accounting* will be the term used to cover the engineering report and record functions necessary for *plant and equipment accounting, real property accounting* and other similar terms of reference.

Application of Data Processing to Property Accounting

Procedures in use under a manual system may be inadequate for a mechanized program. It is essential that the manual procedures be studied first to determine the reasons for the system, and second to ascertain the inadequacies of that system. Research must next establish if the methods being followed are compatible with a mechanized system, and if not, to originate the alterations considered necessary.

The initial mechanization study important in property accounting is a determination of the machine methods that can be adopted for the acquisition of engineering and accounting data for construction projects in the field, the processing and routing of these data in order to reach the property record section in its most convenient and useable form, and finally the utilization of these data to perpetuate corporate property records.

Field Adaptions

Practically all source information, except retirement data, for mechanization of construction reports must originate in the field. At the time an asset, or an item referred to as a facility or unit of property is put into service, through purchase or construction, it becomes a part of corporate real property. Experience has indicated that the sooner the description, classification and cost of the item can be established the greater the accuracy and resultant completeness of property accounting. Field personnel must receive their instructions to accomplish this basic function from one or both of the following:

(a) Directions contained in the AFE or Work Order for the particular project.
(b) Instructions contained in instruction manuals, code books or catalogs.

An Integrated System

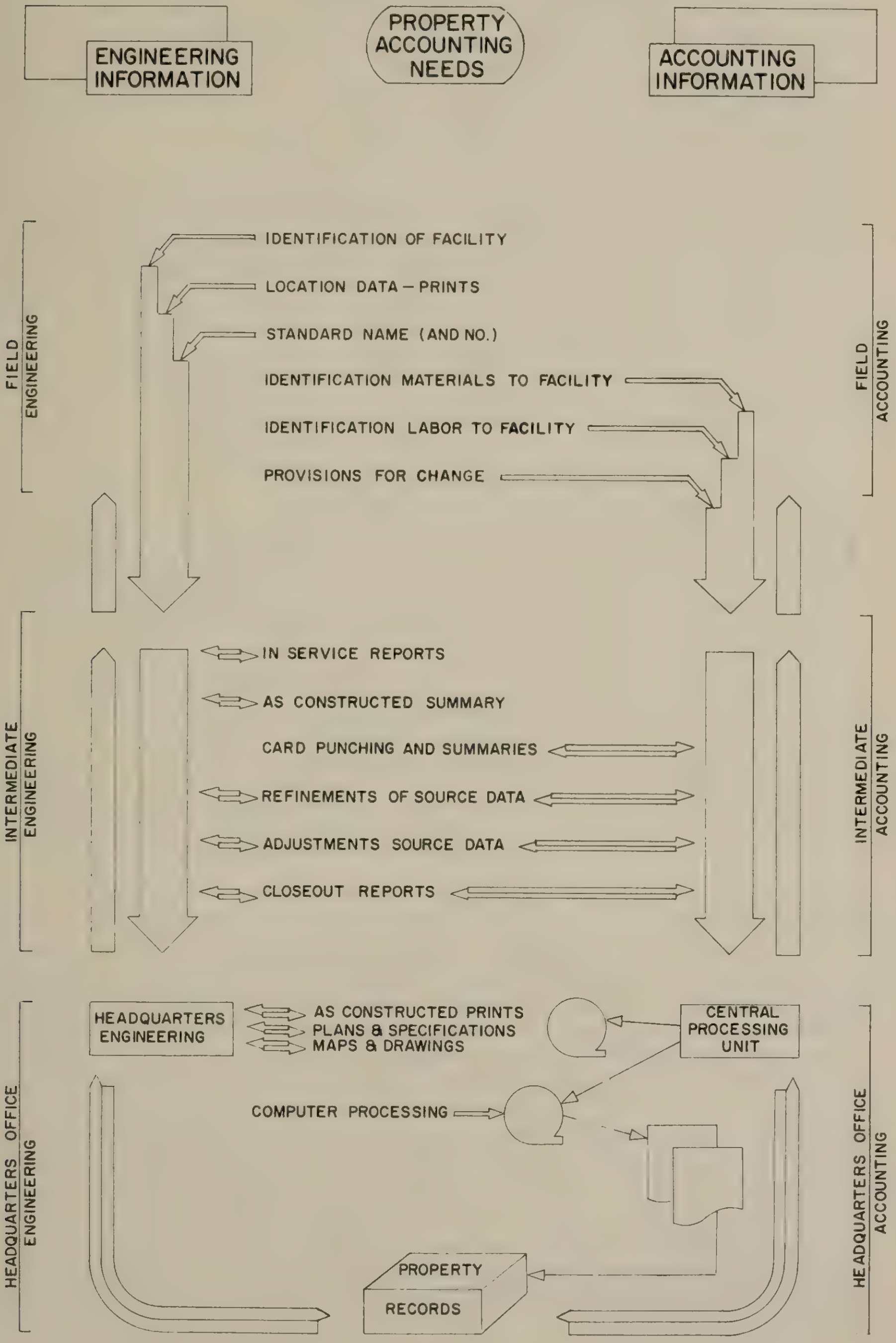
As the future points to many new kinds of computers and the railroad industry calls for research for "total systems" applications, our entire outlook on the acquisition of property source data could change. But for the present, our study of source data in the field for computer processing at the general-office level is predicated on a procedure whereby property accounting is made a part of and integrated with the machine system established, or being established, in the overall accounting system. Likewise, the property accounting system must be tied in with the existing procedures used for the acquisition and routing of engineering data.

In the programming for the conversion of existing railroad manual accounting systems for reporting of cost of labor and material of a construction project, this study hopes to point out the importance of integrating the property accounting needs with the accounting needs. If this is done, one of the basic problems would be resolved—that of relating the classification of charges to separate units of property at the field level. To show the interdependency of the flow of engineering, accounting and property information from the field to the central processing unit and vice versa, a diagram is presented (see page 237) to illustrate the flow of typical accounting and engineering information required in property accounting.

Electronic Data Processing Methods for Railroad AFE Property Accounting

The problem definition of a property accounting conversion from a manual procedure to a computer program confirms the multitude of types of information involved. Engineering plans, specifications and construction procedures are involved in that we are "reconstructing" for the record and classifying property in line with engineering terminology. Stocks of materials and supplies with their corresponding stock numbers and unit prices are involved, since we are classifying property as to its material classification and determining the cost and quantities of material in a unit of property and its component parts through the assembly of the separate material items. Also, we are dealing with the accounting of expenditures, so must depend upon the details from disbursement accounting for the cost of labor and material for the assembly of cost and segregation of cost to the separate units of property. Finally, we are involved in the property records themselves, as they exist today, to provide the only source of information we have as to the description and the cost of the property being retired. However, the latter involves a study of the conversion of property retirements from a manual record to a mechanized system, and this amounts to a separate study of major proportions that will not be covered at this time.

Thus, in order to determine how the railroad industry can work towards a method for computer processing of property, we have attempted to group the methods applicable


ENGINEERING INFORMATION
PROPERTY ACCOUNTING NEEDS
ACCOUNTING INFORMATION
FIELD ENGINEERING
IDENTIFICATION OF FACILITY
LOCATION DATA – PRINTS
STANDARD NAME (AND NO.)
IDENTIFICATION MATERIALS TO FACILITY
IDENTIFICATION LABOR TO FACILITY
PROVISIONS FOR CHANGE
FIELD ACCOUNTING
INTERMEDIATE ENGINEERING
IN SERVICE REPORTS
AS CONSTRUCTED SUMMARY
CARD PUNCHING AND SUMMARIES
REFINEMENTS OF SOURCE DATA
ADJUSTMENTS SOURCE DATA
CLOSEOUT REPORTS
INTERMEDIATE ACCOUNTING
HEADQUARTERS OFFICE ENGINEERING
HEADQUARTERS ENGINEERING
AS CONSTRUCTED PRINTS
PLANS & SPECIFICATIONS
MAPS & DRAWINGS
CENTRAL PROCESSING UNIT
COMPUTER PROCESSING
PROPERTY RECORDS
HEADQUARTERS OFFICE ACCOUNTING

into a few general categories. For the present we have placed all applications under one of three categories, as follows:

(a) Unitized or "tailor-made" AFE.
(b) Unit catalog.
(c) Combination unitized AFE and unit catalog.

Unitized or "Tailor-Made" AFE

This method is characterized by an extensively detailed AFE. All labor and material must be identified with each separate unit of property. Thus, there is considerable emphasis on the detail that must be placed on the AFE primarily at the general-office level. As there is a limited issuance and intended use of manuals and reference material at the field-office level, the AFE must serve as both an engineering construction and property accounting guide.

One carrier's application of this method is being considered, and the following characteristics typical of the installation will be given further study:

(a) Consistency in the methods applied in preparation of AFE and use of standardized nomenclature and phraseology is important.
(b) System-wide codes for units of property or codes for kinds of construction and maintenance operations are not required.
(c) Project codes for each separate item, unit of property or other item on the AFE is required. The code numbers can start with No. 1 on each AFE, running as high as necessary. The codes are useable only for the project to which the numbers are applied and are not interchangeable with project codes of any other project.
(d) Usual separate series of material codes are required.
(e) Standardized description of property units on the AFE is mandatory and the use of same on AFE statement of charges is desirable.
(f) Field or departmental AFE estimate submitted to the general office for issuance of an AFE should include project codes.
(g) Computer output provides an adequate separation of source data to units of property for property accounting but does not provide a basis for further in-line mechanization without later addition of system-wide property unit codes.

Unit Catalog

The catalog method for computer processing of transactions for the construction and retirement of property places maximum emphasis on the advance preparation and use of a unit catalog. The latter provides the "tie" between the general office and the field offices as to what is required as an end result in corporate property accounting. It interprets these needs by providing loose-leaf catalog sheets that are kept up to date in all respects as to unit names and codes, description of property units, explanation of construction and maintenance functions, etc. The system is characterized by predetermined standards and methods for engineering construction and property accounting being in the hands of field offices. There is a minimum use of detail at the general-office level in that a construction authority or AFE need only provide a description of the work to be performed and reference to certain code numbers and typical drawings.

The unit catalog method is being used by certain public utilities and natural gas companies. We have not been in contact with a railroad that is using the method. However, carrier application of the unit catalog will be given consideration through a study of the following:

(a) Issuance of the catalog is an interdepartmental function.

(b) Use of standard or unit names is mandatory.

(c) Catalog sheets must provide for a manual description and numerical code classification for all property classifications.

(d) Considerable indexing and cross indexing is required to insure the use of correct unit names with tie to prime and sub-unit coding.

(e) Material and supplies must all be identified and classified, providing positive identification with numerical code.

(f) Catalog sheets must cover all construction or maintenance functions expected, with appropriate coding.

(g) Typical drawings for construction and maintenance operations must be included as part of the catalog.

(h) Continual updating of the catalog sheets and typical drawings is required.

(i) Catalog instructions cover the accounting for a construction project, together with such information as the company or regulatory agency may require.

Combination Unitized AFE and Unit Catalog

The combination method, to varying degrees, utilizes both the unitized or "tailor-made" AFE and the unit catalog methods. A number of railroads in their computer planning do not appear to be going to either the basic concept of a complete all-purpose catalog system or the basic unitized AFE system. They seem to be using various combinations of both. A variety of different series of code numbers may be used, and in some instances code reference manuals may be used, both typical of the catalog system. However, the carriers still retain most of detailed aspects of the AFE construction authority that have been typical of railroad procedures of the past.

The combination method being used by two carriers has been given consideration and will be pursued to gain additional information. The first of these two has established a fairly elaborate AFE with considerable detail, and also has compiled and issued a number of material and functional pocket-size code books. The other road has compiled a less extensive system of codes which involved only the issue of a small instructional code manual. The following characteristics are to be noted:

(a) The codes are predetermined for system-wide use. In the first instance the carrier's list is a simple, partial, general segregation of major items, while the other carrier provides dual coding, one being a suffix to the AFE number for a breakdown of the AFE for additional groupings for other than labor and material, and the second being a functional code grouping.

(b) Neither method apparently provides coding for a clear-cut distinction of units of property, but rather only partial identification of certain units of property, with identification of certain construction or maintenance operations and identification of labor and material.

(c) The more elaborate method of one of the carriers, in addition to providing for the control, expenditure and accounting of material and labor, also includes coding for the assembly of data for management reports concerning administration of engineering activities, budget control, etc.

(d) The more elaborate coding method of one carrier does not require the inclusion of codes on the request for issuance of an AFE, while the less elaborate system intends that the originating department or field office include the coding on the estimate.

(e) One of the systems differs from those of all other carriers studied in that intermediate offices, geographically distributed on their system, code and prepare punch cards from source documents, transmitting them by transceiver to the central processing unit.

(f) The usual separate series of material codes is required.

(g) The use of standard nomenclature for separate units of property is not as critical in these methods, as the codes used do not necessarily adhere strictly to property units.

(h) Field accounting entails strict adherence to both the AFE instructions and the code books or manuals.

(i) For those studied, computer output provides only a partial separation of source data to separate units of property because of the inadequacies of the codes; thus the system does not provide a basis for further in-line mechanization as far as summaries by separate units of property are concerned, without inserting additional segregation of codes or combination of codes.

Report on Assignment 6

Valuation and Depreciation (a) Current Developments in Connection with Regulatory Bodies and Courts

C. R. Dolan (chairman, subcommittee), R. B. Aldridge, G. R. Berquist, P. E. Bierman, J. B. Byars, J. R. Clayton, P. L. Conway, Jr., R. L. Ealy, R. F. Garner, W. S. Gates, Jr., E. W. Gibson, J. E. Hebbron, M. J. Hebert, L. W. Howard, R. D. Igou, R. A. Johnson, R. A. Lariviere, J. E. Manthey, C. F. Olson, C. H. Rapp, C. S. Robey, E. J. Rockefeller, J. B. Styles, H. R. Williams.

ICC Bureau of Accounts

The valuation work of the Section of Valuation and Reports was principally in the area of railroads and pipelines. Tentative and final valuation reports were prepared for pipeline carriers, and by the end of the year statements will be completed showing the elements of values for all Class I line-haul and switching and terminal companies as of December 31, 1963.

As of October 1, 1964, pipeline and rail carriers were delinquent in the filing of valuation reports with the Bureau as follows: 2 line-haul companies for 1959, 2 line-haul companies for 1960, 4 line-haul and 2 switching and terminal companies for 1961, and 19 line-haul and 6 switching and terminal companies for 1962. Valuation reports covering property changes for 1963 have been received from 14 line-haul and switching and terminal companies and 49 pipeline carriers.

The total authorized personnel for the Section of Valuation and Reports on October 1, 1964, was 35. Of this total 23 were assigned to valuation and depreciation work.

During the year the Commission released the Schedule of Annual Indices for Carriers by railroad and pipeline for the year 1963.

Simplification of BV–588 returns: Further progress in this matter has been suspended pending the outcome of legislation to be introduced in the 89th Congress amending the Valuation Act to relieve the Commission of the mandatory reporting by carrier of quantities in reporting changes in their properties.

Formation of the Railroad Advisory Committee on Equipment and Roadway Property

For many years the Bureau of Valuation and later the Section of Valuation, Bureau of Accounts, used the services of several railroad committees in the conduct of its work. The Western Railroad Group Price Committee, the Joint Signal Committee, and the Joint Equipment Committee assisted the Bureau's engineers in the task of collecting cost data and determining yearly railroad construction indices.

In 1963 the Commission determined that the continued use of these committees was not in keeping with the provisions of Executive Order 11007; consequently they were dissolved and a new committee called the Railroad Advisory Committee on Equipment and Roadway Property was formed at that time.

The committee was established to cooperate with the Bureau of Accounts in railroad equipment and roadway property matters generally, and in the area of collecting, summarizing and evaluating cost data that are used in developing annual railroad construction indices.

The committee membership consists of Class I and Class II railroad company employees selected for membership by the Bureau of Accounts, with an employee of the Bureau serving as chairman of the committee.

The Advisory Committee was subdivided into 10 working groups or subcommittees based on the homogenous grouping of items of railroad property for which an annual review and cost analysis will be made. Assignment of committee members to specific subcommittees was predicated on the availability of personnel from various regions of the country so that, to the extent possible, an eastern, southern, midwestern and far-western carrier would be represented on each subcommittee. Other factors considered were members' past committee experience and their present area of responsibility in the industry. A list of the subcommittees and the subcommittee chairman follows:

Subcommittee	*Title*	*Chairman*
No. 1	Grading, Tunnels and Bridges	C. J. Cosner
No. 2	Timber, Concrete, Pipe and Freight Rates	M. C. Wolf
No. 3	Rail	E. N. Perry
No. 4	Other Track Material	R. D. Igou
No. 5	Tracklaying and Surfacing	J. E. Hebbron
No. 6	Ballast, Crossings and Fences	C. R. Dolan
No. 7	Buildings	C. F. Olson
No. 8	Communications and Power Transmission Systems	J. H. Robinson
No. 9	Machinery and Tools, Locomotives, Freight and Passenger Train Cars, and Floating and Other Work Equipment	L. M. Rothberger
No. 10	Special Assignments	W. J. Pease

On June 18, 1964, the first annual meeting of the Committee was held in Washington, D. C., for the purpose of formulating the final 1963 Railroad Construction Indices. Each subcommittee chairman submitted a report on the activity and problems encountered in fulfilling their respective subcommittee assignments. From the discussion and questions raised at this meeting, it was evident that the committee members needed guidance and a set of working tools in order that they might accomplish their primary objective, namely, to assist the Bureau of Accounts in the area of collecting, summarizing and evaluating carrier contract and manufacturer's cost data which are used in the development of annual railroad construction indices.

At the September meeting of Committee 11, the Bureau's chief valuation engineer outlined the elements of cost that were used in arriving at the basic engineering report prices and the corresponding cost elements that should be considered in developing the current average annual prices and the resultant yearly construction indices. Tentative working forms, developed by the Engineering Branch, Section of Valuation and Reports, were submitted to the subcommittee chairmen for their consideration and guidance in obtaining uniform reporting of future cost data by the committee members and carrier representatives.

Report on Assignment 7

Revisions and Interpretations of ICC Accounting Classifications

R. D. Igou (chairman, subcommittee), C. W. Meyer (vice chairman, subcommittee), P. L. Conway, Jr., C. R. Dolan, W. S. Gates, Jr., W. M. Hager, J. G. Maher, W. J. Pease, C. H. Rapp, F. A. Roberts, C. S. Robey, H. B. Sampson, J. R. Traylor.

This is a progress report, presented as information.

The Interstate Commerce Commission has issued under its order of October 15, 1963, Docket No. 32153, published in the Federal Register on October 26, 1963, rules pertaining to the cancellation, reclassification and retention of General Expenditure Accounts 71 to 77, incl.

The ICC Bureau of Accounts has issued Accounting Series Circular No. 133A, dated September 27, 1963, covering the filing of journal entries, and 10 supplements to Accounting Series Circular No. 133 to instruct, clarify, implement and assist carriers in applying the revised accounting and valuation rules in the Commission's orders of April 17 and October 15, 1963.

The ten supplements cover the following instructions:

Supplement No. 1, issued August 26, 1963. Instructions for railroads constructed about the time the time basic valuations were being made or thereafter and original cost was determined from the records.

Supplement No. 2, issued August 26, 1963. Instructions for railroads which were organized (or reorganized) and their property purchased at receivership sale, or the property was otherwise acquired, from about the time of basic valuations to about 1938, when the special "acquisition adjustment" account was made effective. (This supplement is modified to some extent in Supplement No. 4.)

Supplement No. 3, issued September 9, 1963. Instructions for railroads which have been specifically authorized to amortize their whole property.

Supplement No. 4, issued October 23, 1963. Instructions for computing amounts to be included in each primary property account, including specific instructions for Land Account 2 and Track Accounts 9, 10 and 11, and for preparing a columnar form of supporting statement. This supplement also covers the procedure for handling differences in valuation figures. The supplement also contains a modification in Supplement No. 2.

Supplement No. 5, issued November 15, 1963. Instructions for disposition of amounts shown in the valuation figures for Accounts 15 and 40. These two accounts have been cancelled from the accounting rules.

Supplement No. 6, issued November 15, 1963. Clarification and explanation of instructions in the text of Account 80 pertaining to clearance of amounts from that account when property is retired from service.

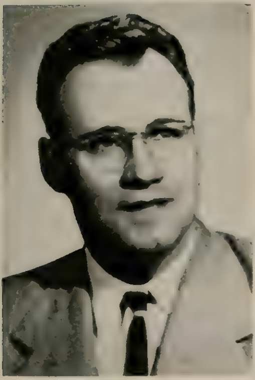
Supplement No. 7, issued December 10, 1963. Instructions to implement and to assist carriers in applying the rules in the Commission's order of October 15, 1963, which cancelled primary property Accounts 72, 73, 74 and 75. Items of general expenditures previously included in those accounts are now includible in Account 77, Other Expenditures—General. This supplement also refers to the Commission's order of April 17, 1963, which requires general adjustment of primary property accounts.

Supplement No. 8, issued January 31, 1964. Instructions and clarification of requirements to be followed by railroads in preparing B.V. Form 588–R reports as a result of modifications in the valuation rules made effective in the Commission's order dated April 17, 1963.

Supplement No. 9, issued June 15, 1964. Procedure for settlement of differences between accounting records and valuation reports pursuant to the Commission's order of April 17, 1963.

Supplement No. 10, issued June 15, 1964. Procedure for clearing Account 80, Other Elements of Investment, as required by order dated April 17, 1963.

Report of Committee 28—Clearances



R. L. Williams,
Chairman

J. A. Crawford,
Vice Chairman

B. Bristow
R. D. Erhardt
C. W. Hamilton
E. E. Mills
J. E. Beran
M. E. Vosseller
J. D. Batchelder
C. O. Bird
E. S. Birkenwald
D. H. Brown
S. M. Dahl
R. T. Dedow
J. E. Fanning (E)
J. E. Good
J. G. Greenlee
W. T. Hammond
A. R. Harris (E)
W. F. Hart (E)
C. F. Intlekofer
J. L. Kampwirth
W. I. King
W. P. Kobat
M. L. Koehler
A. J. Kozak
J. R. Moore
M. D. Murphy
R. C. Nissen
F. B. Persels
C. E. Peterson
R. C. Rankin
W. S. Ray
H. L. Read
R. A. Skooglun
J. W. Wagner
C. R. Wallace
J. W. Wallenius

Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 28.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, submitted for adoption .... page 246

2. Compilation of the railroad clearance requirements of the various states.
   No report. No known changes have occurred since the previous report.

3. New methods and electronic devices for recording measurements of clearance of structures along right of way and overall dimensions of cars and loads in yards and at interchange points, looking to the possible use of a computer program for routing high and wide loads.

   No report. No further progress has been made since publication of the preliminary report in Bulletin 582, December 1963.

5. Clearance allowances to provide for vertical and horizontal movements of equipment due to lateral play, wear and spring deflection, collaborating with the Mechanical Division, AAR.

   No report. No additional tests have been made on TTX cars since those of May 1961 which, as reported in Bulletin 582, December 1963, were considered inconclusive.

6. Feasibility of formulating a more complete method, for use of Transportation Departments, in reporting loads of excessive dimensions to minimize necessity for requesting additional information, collaborating with the Mechanical Division, AAR.

   Brief progress report, presented as information .... page 252

8. Review present methods of presenting published clearance information:
   (a) To determine how this can be simplified and/or standardized.
   Final report, including data submitted for adoption .... page 252
   (b) To determine the feasibility of including in the Official Railway Equipment Register the light weight and height of center of gravity of all heavy-duty flat cars to aid clearance personnel in routing shipments of excessive weight.
   Progress report, submitted as information .... page 255

9. Review clearance records of various railroads, looking to developing a standardized method for charting all obstructions.

   Final report, including material submitted for adoption .... page 255

THE COMMITTEE ON CLEARANCES,
R. L. WILLIAMS, *Chairman.*

AREA Bulletin 589, December 1964.

Report on Assignment 1

Revision of Manual

B. Bristow (chairman, subcommittee), E. S. Birkenwald, J. A. Crawford, J. E. Fanning, A. R. Harris, W. F. Hart, W. P. Kobat, M. L. Koehler, E. E. Mills, J. R. Moore, R. C. Rankin, J. W. Wagner, R. L. Williams.

Your committee submits for adoption the following recommendations with respect to the Manual:

Page 28–3–1

PART 3—EQUIPMENT DIAGRAMS

Reapprove with the following revisions:

Page 28–3–1. Delete Fig. 1 and substitute therefor revised Fig. 1—Equipment Diagram Unrestricted for Interchange Service, presented herewith.

Following page 28–3–1, add the following new diagrams, presented herewith:

Fig. 2—Maximum Width of Cars with Various Truck Centers.

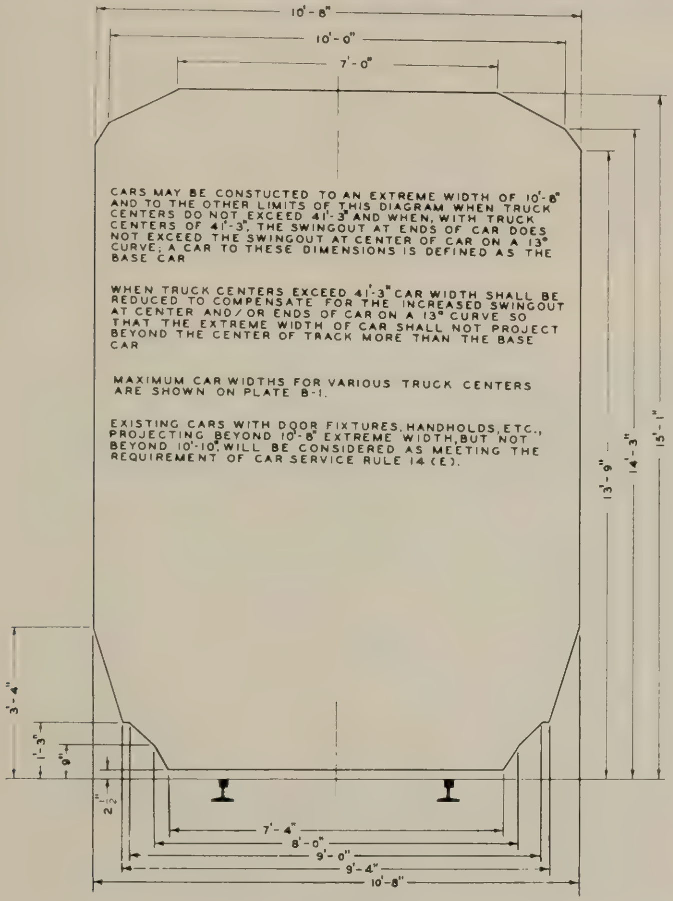
Fig. 3—Equipment Diagram for Limited Interchange Service.

Fig. 4—Maximum Width of Cars with Various Truck Centers.

Fig. 5—Outline Diagram for Single Loads, Without End Overhang, on Open-Top Cars.

These five figures are the same as the equipment diagrams of the Mechanical Division, AAR, and are recommended for adoption and publication in the AREA Manual for convenient reference only.

EQUIPMENT DIAGRAM UNRESTRICTED FOR INTERCHANGE SERVICE*



CARS MAY BE CONSTUCTED TO AN EXTREME WIDTH OF 10'-8" AND TO THE OTHER LIMITS OF THIS DIAGRAM WHEN TRUCK CENTERS DO NOT EXCEED 41'-3" AND WHEN, WITH TRUCK CENTERS OF 41'-3", THE SWINGOUT AT ENDS OF CAR DOES NOT EXCEED THE SWINGOUT AT CENTER OF CAR ON A 13° CURVE; A CAR TO THESE DIMENSIONS IS DEFINED AS THE BASE CAR

WHEN TRUCK CENTERS EXCEED 41'-3" CAR WIDTH SHALL BE REDUCED TO COMPENSATE FOR THE INCREASED SWINGOUT AT CENTER AND/OR ENDS OF CAR ON A 13° CURVE SO THAT THE EXTREME WIDTH OF CAR SHALL NOT PROJECT BEYOND THE CENTER OF TRACK MORE THAN THE BASE CAR

MAXIMUM CAR WIDTHS FOR VARIOUS TRUCK CENTERS ARE SHOWN ON PLATE B-1.

EXISTING CARS WITH DOOR FIXTURES, HANDHOLDS, ETC., PROJECTING BEYOND 10'-8" EXTREME WIDTH, BUT NOT BEYOND 10'-10", WILL BE CONSIDERED AS MEETING THE REQUIREMENT OF CAR SERVICE RULE 14 (E).

FIG. I

THE 2-1/2" ABOVE TOP OF RAIL IS ABSOLUTE MINIMUM UNDER ANY AND ALL CONDITIONS OF LADING, OPERATION, AND MAINTENANCE

ALL NEW OR REBUILT CARS SHOULD BE SO DESIGNED THAT NO PART OF CAR SHALL BE LESS THAN 2-3/4" ABOVE THE TOP OF THE RUNNING RAIL UNDER ALL ALLOWABLE WEAR AND SPRING DEFLECTION CONDITIONS THOSE ROADS USING MULTIPLE WEAR WHEELS MAY FIND IT NECESSARY IN MAINTAINING THE 2-3/4" MINIMUM CLEARANCE, TO COMPENSATE FOR WHEELS WORN CLOSE TO THE CONDEMNING LIMIT BY REPLACING WHEEL AND AXLE SETS, BEARINGS OR WEDGES.

* THIS DIAGRAM IS THE SAME AS PLATE B OF THE MECHANICAL DIVISION, A A R, AND IS INCLUDED IN THE A R E A MANUAL FOR CONVENIENT REFERENCE.

MAXIMUM WIDTH OF CARS WITH VARIOUS TRUCK CENTERS ✱

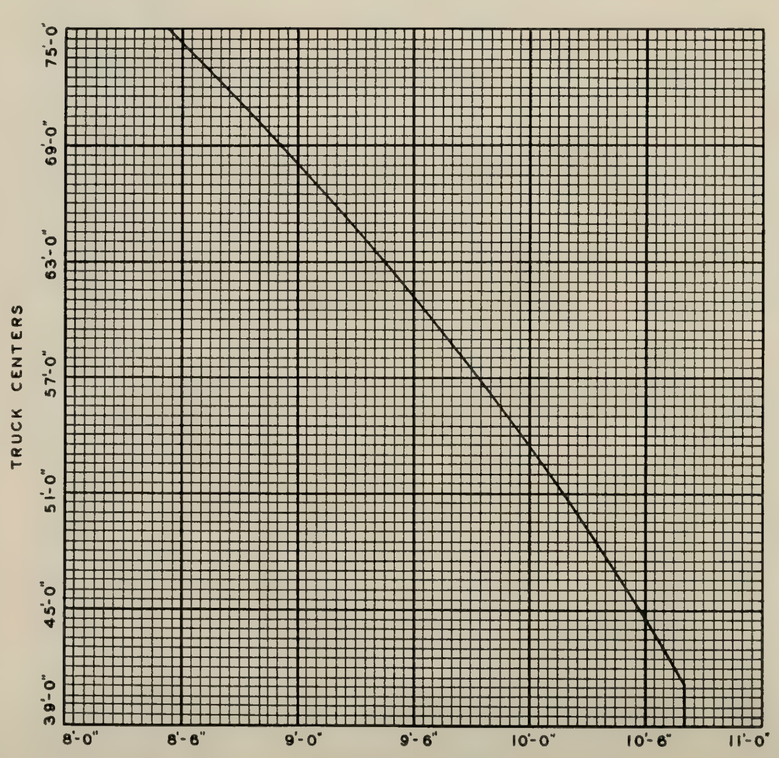
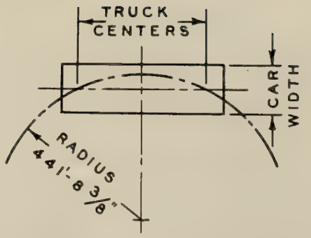


FIG. 2



THE REDUCTION IN WIDTH IS PREDICATED ON THE BASE CAR DEFINED ON PLATE B, AND ON A 13° CURVE.

BASE CAR – (EXTREME WIDTH 10'-8"
(TRUCK CENTERS 41'-3"

13° CURVE = 441'-8 3/8" RADIUS.

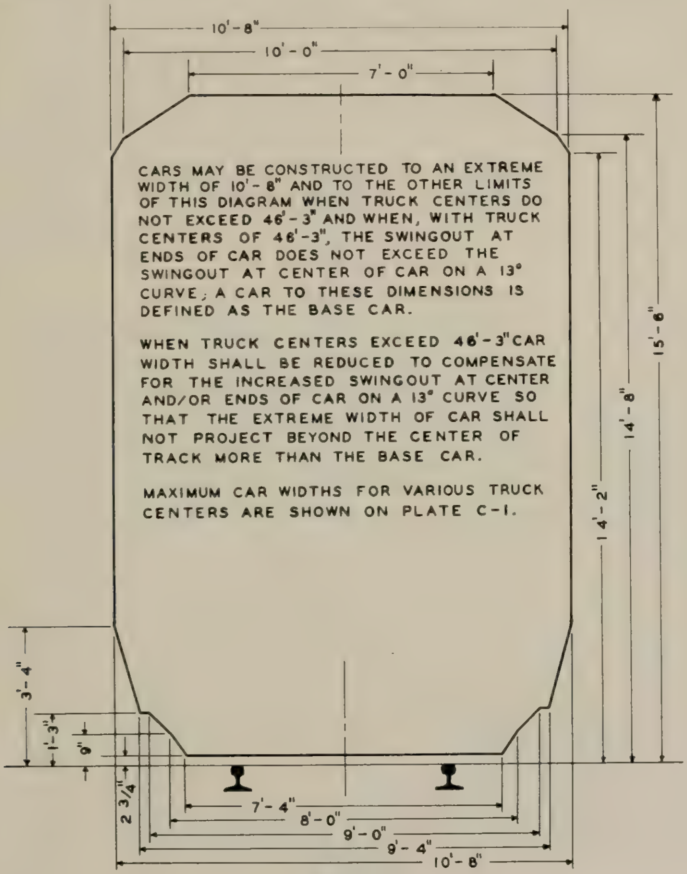
MAXIMUM SWINGOUT AT CENTER OF CAR WITH 41'-3" TRUCK CENTERS = 5 3/4".

NOTE: THE MAXIMUM WIDTHS SHOWN ARE BASED ON THE SWINGOUT AT CENTER OF CAR WHICH USUALLY GOVERNS, BUT ON CARS WITH LONG OVERHANGS THE SWINGOUT AT ENDS OF CAR MUST ALSO BE CHECKED.

✱ THIS DIAGRAM IS THE SAME AS PLATE B-1 OF THE MECHANICAL DIVISION, A A R, AND IS INCLUDED IN THE A R E A. MANUAL FOR CONVENIENT REFERENCE.

NOTE: FOR USE WITH PLATE "B"

EQUIPMENT DIAGRAM FOR LIMITED INTERCHANGE SERVICE *



CARS MAY BE CONSTRUCTED TO AN EXTREME WIDTH OF 10'-8" AND TO THE OTHER LIMITS OF THIS DIAGRAM WHEN TRUCK CENTERS DO NOT EXCEED 46'-3" AND WHEN, WITH TRUCK CENTERS OF 46'-3", THE SWINGOUT AT ENDS OF CAR DOES NOT EXCEED THE SWINGOUT AT CENTER OF CAR ON A 13° CURVE; A CAR TO THESE DIMENSIONS IS DEFINED AS THE BASE CAR.

WHEN TRUCK CENTERS EXCEED 46'-3" CAR WIDTH SHALL BE REDUCED TO COMPENSATE FOR THE INCREASED SWINGOUT AT CENTER AND/OR ENDS OF CAR ON A 13° CURVE SO THAT THE EXTREME WIDTH OF CAR SHALL NOT PROJECT BEYOND THE CENTER OF TRACK MORE THAN THE BASE CAR.

MAXIMUM CAR WIDTHS FOR VARIOUS TRUCK CENTERS ARE SHOWN ON PLATE C-1.

FIG. 3

THE 2 3/4" ABOVE TOP OF RAIL IS ABSOLUTE MINIMUM UNDER ANY AND ALL CONDITIONS OF LADING, OPERATION, AND MAINTENANCE.

* THIS DIAGRAM IS THE SAME AS PLATE C OF THE MECHANICAL DIVISION, AAR, AND IS INCLUDED IN A R E A MANUAL FOR CONVENIENT REFERENCE. FOR RESTRICTIONS APPLICABLE TO THIS DIAGRAM SEE "RAILWAY LINE CLEARANCES".

MAXIMUM WIDTH OF CARS WITH VARIOUS TRUCK CENTERS ✱

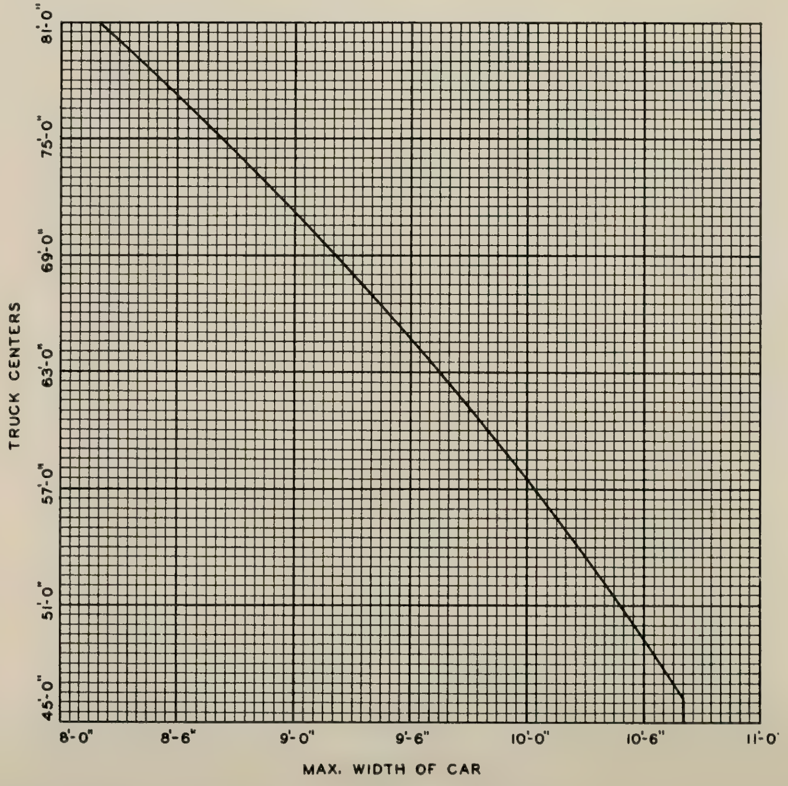
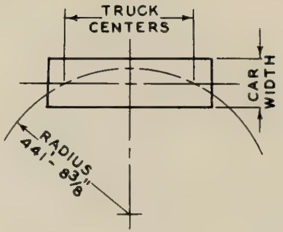


FIG. 4



THE REDUCTION IN WIDTH IS PREDICATED ON THE BASE CAR, DEFINED ON PLATE C, AND ON A 13° CURVE.

BASE CAR – (EXTREME WIDTH 10'-8"
(TRUCK CENTERS 46'-3"

13° CURVE = 441'-8$\frac{3}{8}$" RADIUS.

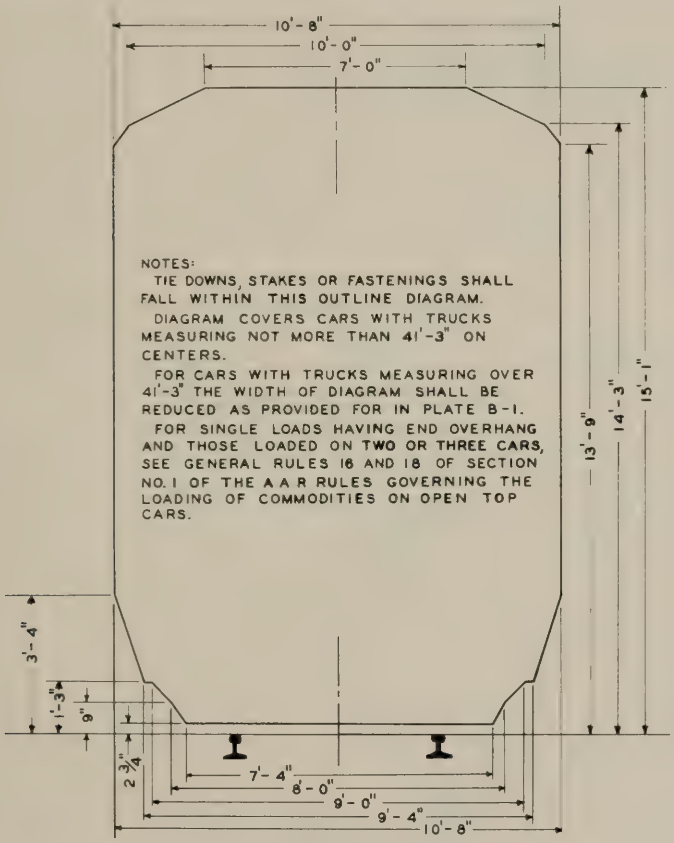
MAXIMUM SWINGOUT AT CENTER OF CAR WITH 46'-3" TRUCK CENTERS = 7$\frac{1}{4}$".

NOTE: THE MAXIMUM WIDTHS SHOWN ARE BASED ON THE SWINGOUT AT CENTER OF CAR WHICH USUALLY GOVERNS, BUT ON CARS WITH LONG OVERHANGS THE SWINGOUT AT ENDS OF CAR MUST ALSO BE CHECKED.

✱ THIS DIAGRAM IS THE SAME AS PLATE C-1 OF THE MECHANICAL DIVISION, AAR, AND IS INCLUDED IN THE AREA MANUAL FOR CONVENIENT REFERENCE.

NOTE: FOR USE WITH PLATE "C"

OUTLINE DIAGRAM FOR SINGLE LOADS, WITHOUT END OVERHANG, ON OPEN TOP CARS ✱



NOTES:

TIE DOWNS, STAKES OR FASTENINGS SHALL FALL WITHIN THIS OUTLINE DIAGRAM.

DIAGRAM COVERS CARS WITH TRUCKS MEASURING NOT MORE THAN 41'-3" ON CENTERS.

FOR CARS WITH TRUCKS MEASURING OVER 41'-3" THE WIDTH OF DIAGRAM SHALL BE REDUCED AS PROVIDED FOR IN PLATE B-1.

FOR SINGLE LOADS HAVING END OVERHANG AND THOSE LOADED ON TWO OR THREE CARS, SEE GENERAL RULES 16 AND 18 OF SECTION NO. 1 OF THE A A R RULES GOVERNING THE LOADING OF COMMODITIES ON OPEN TOP CARS.

FIG. 5

SHIPMENTS WITH MEASURMENTS EXCEEDING THOSE SHOWN IN THIS DIAGRAM SHOULD BE CLEARED FOR ROUTE IN RAILWAY LINE CLEARANCES OR WITH THE ORIGINATING ROAD HAUL CARRIER.

✱ THIS DIAGRAM IS THE SAME AS THE OUTLINE DIAGRAM OF THE MECHANICAL DIVISION, AAR, AND IS INCLUDED IN A R E A MANUAL FOR CONVENIENT REFERENCE. FOR RESTRICTIONS APPLICABLE TO THIS DIAGRAM SEE "RAILWAY LINE CLEARANCES."

Report on Assignment 6

Feasibility of Formulating a More Complete Method, for Use of Transportation Departments, in Reporting Loads of Excessive Dimensions to Minimize Necessity of Requesting Additional Information

Collaborating with the Mechanical Division, AAR

J. E. Beran (chairman, subcommittee), D. H. Brown, J. A. Crawford, R. T. Dedow, J. E. Good, W. T. Hammond, W. I. King, J. R. Moore, M. D. Murphy, F. B. Persels, W. S. Ray, H. L. Read, M. E. Vosseller, C. R. Wallace, R. L. Williams.

Your committee has developed a basic draft of the required information. Circulation of this draft produced many suggestions which are in the process of evaluation. After this work has been completed and results approved, and collaboration with the Mechanical Division, AAR, has been effected, a report will be presented to the Association.

Report on Assignment 8

Review Present Methods of Presenting Published Clearance Information

(a) To Determine How This Can Be Simplified and/or Standardized,

(b) To Determine the Feasibility of Including in the Official Railway Equipment Register the Light Weight and Height of Center of Gravity of all Heavy-Duty Flat Cars to Aid Clearance Personnel in Routing Shipments of Excessive Weight

J. A. Crawford (chairman, subcommittee), J. D. Batchelder, J. E. Beran, B. Bristow, D. H. Brown, R. D. Erhardt, J. E. Good, J. G. Greenlee, C. W. Hamilton, W. T. Hammond, C. F. Intlekofer, J. L. Kampwirth, W. P. Kobat, R. C. Nissen, C. E. Peterson, R. C. Rankin, W. S. Ray, H. L. Read, R. A. Skooglun, R. L. Williams.

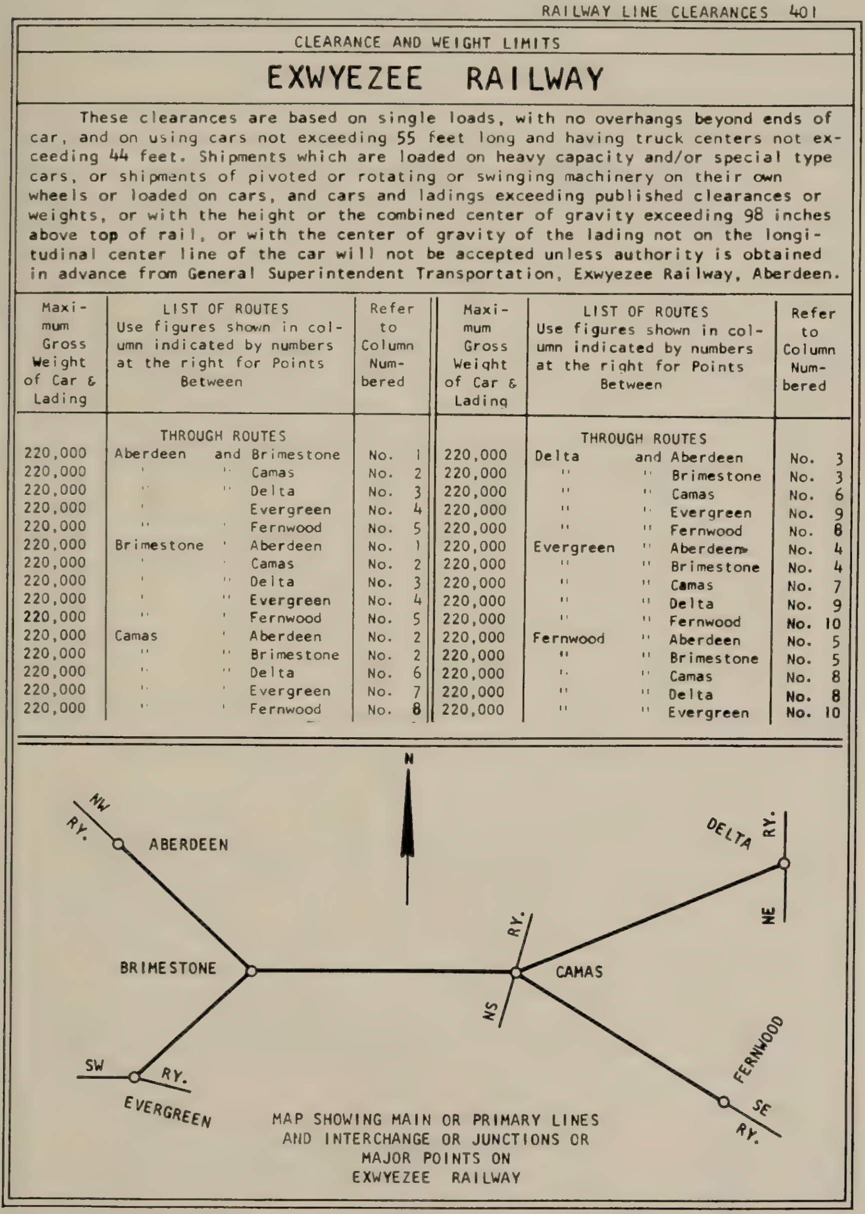
Under part (a) of Assignment 8 your committee recommends for adoption and publication under Miscellaneous, Chapter 28, of the Manual, the following "Suggested Method of Presenting Published Clearance."

SUGGESTED METHOD OF PRESENTING PUBLISHED CLEARANCES

The suggested method of presenting published clearances includes the following data:

1. Clearances (and weight limits) for routes between interchange points, junctions or other major joints on a railroad.
2. An index in alphabetical order for the routes.
3. A column number assigned to each route.
4. A small map showing the lines and the interchange points, junctions or other major points involved in the routes.
5. Clearances based upon cars 55 ft long with truck centers of 44 ft.

A mock-up of a representation for a fictitious railway for inclusion in the publication *Railway Line Clearances* is presented on the following pages. This mock-up is



RAILWAY LINE CLEARANCES 401

CLEARANCE AND WEIGHT LIMITS

EXWYEZEE RAILWAY

These clearances are based on single loads, with no overhangs beyond ends of car, and on using cars not exceeding 55 feet long and having truck centers not exceeding 44 feet. Shipments which are loaded on heavy capacity and/or special type cars, or shipments of pivoted or rotating or swinging machinery on their own wheels or loaded on cars, and cars and ladings exceeding published clearances or weights, or with the height or the combined center of gravity exceeding 98 inches above top of rail, or with the center of gravity of the lading not on the longitudinal center line of the car will not be accepted unless authority is obtained in advance from General Superintendent Transportation, Exwyezee Railway, Aberdeen.

Maximum Gross Weight of Car & Lading	LIST OF ROUTES Use figures shown in column indicated by numbers at the right for Points Between	Refer to Column Numbered	Maximum Gross Weight of Car & Lading	LIST OF ROUTES Use figures shown in column indicated by numbers at the right for Points Between	Refer to Column Numbered
	THROUGH ROUTES			THROUGH ROUTES	
220,000	Aberdeen and Brimestone	No. 1	220,000	Delta and Aberdeen	No. 3
220,000	" " Camas	No. 2	220,000	" " Brimestone	No. 3
220,000	" " Delta	No. 3	220,000	" " Camas	No. 6
220,000	" Evergreen	No. 4	220,000	" " Evergreen	No. 9
220,000	" " Fernwood	No. 5	220,000	" " Fernwood	No. 8
220,000	Brimestone " Aberdeen	No. 1	220,000	Evergreen " Aberdeen	No. 4
220,000	" " Camas	No. 2	220,000	" " Brimestone	No. 4
220,000	" " Delta	No. 3	220,000	" " Camas	No. 7
220,000	" " Evergreen	No. 4	220,000	" " Delta	No. 9
220,000	" " Fernwood	No. 5	220,000	" " Fernwood	No. 10
220,000	Camas " Aberdeen	No. 2	220,000	Fernwood " Aberdeen	No. 5
220,000	" " Brimestone	No. 2	220,000	" " Brimestone	No. 5
220,000	" " Delta	No. 6	220,000	" " Camas	No. 8
220,000	" " Evergreen	No. 7	220,000	" " Delta	No. 8
220,000	" " Fernwood	No. 8	220,000	" " Evergreen	No. 10

MAP SHOWING MAIN OR PRIMARY LINES
AND INTERCHANGE OR JUNCTIONS OR
MAJOR POINTS ON
EXWYEZEE RAILWAY

402 RAILWAY LINE CLEARANCES

CLEARANCE AND WEIGHT LIMITS

EXWYEZEE RAILWAY

Height Above Top of Rail	THROUGH CLEARANCES											Height Above Top of Rail
ft.in.	No. 1 Width ft.in.	No. 2 Width ft.in.	No. 3 Width ft.in.	No. 4 Width ft.in.	No. 5 Width ft.in.	No. 6 Width ft.in.	No. 7 Width ft.in.	No. 8 Width ft.in.	No. 9 Width ft.in.	No. 10 Width ft.in.	No. 11 Width ft.in.	ft.in.
20 0	5 10					5 10		4 0				20 0
19 9	10 6	10 6	10 6		5 0	10 6		5 0				19 9
19 6	12 0	11 0	11 0	12 0	6 0	12 0	11 0	6 0	11 0	6 0		19 6
19 3		11 6	11 6		7 0		11 6	7 0	11 6	7 0		19 3
19 0		12 0	12 0		8 0		12 0	8 0	12 0	8 0		19 0
18 9					9 0			9 0		9 0		18 9
18 6					10 0			10 0		10 0		18 6
18 3					11 0			11 0		11 0		18 3
18 0					11 6			11 6				18 0
3 0			12 0			12 0			12 0			3 0
2 9			11 9			11 9			11 9			2 9
2 6	12 0	12 0	11 6	12 0		11 6	12 0		11 6			2 6
2 3	11 6	11 6	11 3	11 6	11 6	11 3	11 6	11 6	11 3	11 6		2 3
2 0	11 0	11 0	11 0	11 0	11 0	11 0	11 0	11 0	11 0	11 0		2 0
1 9			10 9			10 9			10 9			1 9
1 6			10 6			10 6			10 6			1 6
1 3			10 3			10 3			10 3			1 3
1 0			10 0			10 0			10 0			1 0
0 9	11 0	11 0	9 9	11 0	11 0	9 9	11 0	11 0	9 9	11 0		0 9
0 6	8 0	8 0	8 0	8 0	8 0	8 0	8 0	8 0	8 0	8 0		0 6
0 3												0 3
0 0												0 0

NOTE; Maximun gross weight of car and lading is shown in List of Routes in this Railway's representation.

prepared to illustrate a representation which includes all five of the items listed above. It is relatively basic and includes only a small number of routes; however, the method can be used for any number of routes that might be required for a particular railroad's representation.

The mock-up is illustrative only. If a representation of this method is used, the size and style of type will be that normally used by the publication.

(Note: Each railroad should include in its representation any notes which may be necessary, including, but not limited to, notes with respect to (a) routes on which the Outline Diagram for Single Loads, Without End Overhang, On Open-Top Cars, of the Mechanical Division, AAR, is applicable and (b) routes on which Plate C of the Mechanical Division is applicable.)

Under part (b) of Assignment 8, the following brief progress report is presented as information.

Your committee has requested the secretary's office to progress with the publisher of the *Official Railway Equipment Register* the matter of including in that publication the light weight and height of center of gravity of all heavy-duty flat cars, the policy of the Association precluding your committee from communicating with the publication directly. The secretary's office requested additional information for its use in progressing the subject, and this has been furnished. Further activity will depend upon advice received from the secretary's office as to the outcome of its negotiations.

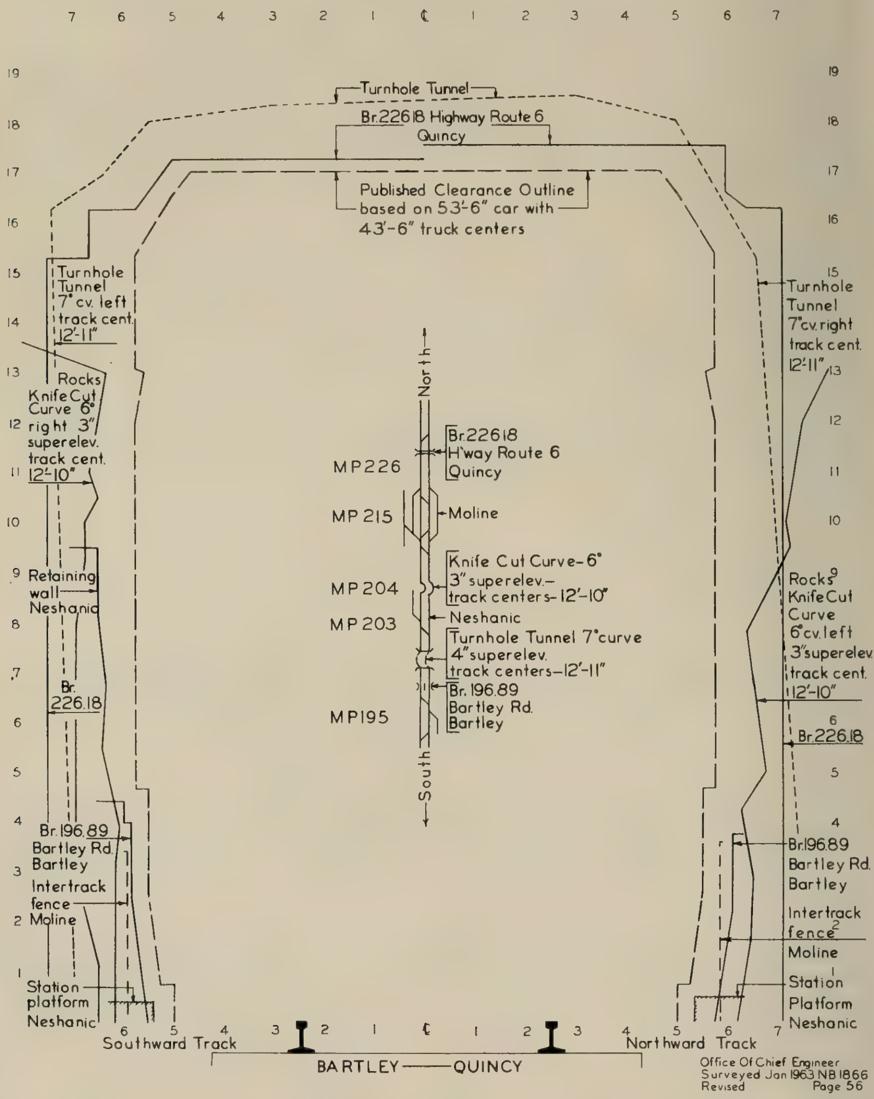
Report on Assignment 9

Review Clearance Records of Various Railroads, Looking to Developing a Standardized Method for Charting all Obstructions

M. E. Vosseller (chairman, subcommittee), J. D. Batchelder, J. E. Beran, C. O. Bird, E. S. Birkenwald, B. Bristow, J. A. Crawford, S. M. Dahl, R. T. Dedow, R. D. Erhardt, C. W. Hamilton, C. F. Intlekofer, J. L. Kampwirth, M. L. Koehler, A. J. Kozak, J. R. Moore, C. E. Peterson, R. C. Rankin, H. L. Read, J. W. Wagner, J. W. Wallenius, R. L. Williams.

Your committee recommends for adoption and publication under Miscellaneous, Chapter 28, of the Manual, the accompanying chart (see page 256) entitled "Suggested Method for Charting all Obstructions," along with the explanatory notes shown thereon. This chart was published as information in the committee's report last year in Bulletin 582, December 1963.

SUGGESTED METHOD FOR CHARTING ALL OBSTRUCTIONS



This chart shows clearance obstructions and critical areas relative to the movement of high and wide loads over a given territory on a hypothetical railroad. Also shown is pertinent information to be used in clearing a load through each restrictive area.

It is recognized that there are various requirements and standards established by individual carriers, and the form of the chart may be modified to fit best the particular need.

Report of Committee 22—Economics of Railway Labor

M. S. Reid, *Chairman*

H. W. Kellogg,
Vice Chairman

L. C. Gilbert, *Secretary*
N. H. Williams
J. R. Miller
J. T. Sullivan
F. H. McGuigan, 3rd
G. E. Warfel
A. D. Alderson
M. B. Allen
J. A. Barnes
J. F. Beaver
J. G. Begley
O. C. Benson
E. J. Brown
R. F. Bush
J. L. Cann
L. B. Cann, Jr.
R. H. Carpenter
J. A. Caywood
A. B. Chaney (E)
W. E. Chapman
R. E. Clancy
S. A. Cooper
P. A. Cosgrove
C. G. Davis
M. H. Dick
L. E. Donovan
W. M. S. Dunn
J. E. Eisemann
F. J. Farish
R. L. Fox
J. M. Gilmore
J. K. Gloster
K. H. Hanger (E)
V. C. Hanna
Gene L. Harris
W. W. Hay
R. B. Hayslip
W. H. Hoar
J. O. Holladay
Claude Johnston
W. J. Jones
R. H. Jordan
T. L. Kanan
M. D. Kenyon
H. E. Kirby
L. A. Loggins
J. M. Lowry
T. D. Mason
R. G. Maughan
R. L. Mays
C. E. McEntee
H. C. Minteer
J. A. Naylor
G. M. O'Rourke (E)
C. W. Owens
C. T. Popma
R. W. Preisendefer
D. E. Rudisill
G. E. Scholze
H. W. Seeley
R. G. Simmons
J. S. Snyder
W. B. Stackhouse
John Stang
W. B. Throckmorton
John T. Ward
H. E. Wilson
F. R. Woolford
B. J. Worley
C. R. Wright (E)
Committee

(E) Member Emeritus.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 22.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   No report. Chapter 22 of the Manual is not presently in need of revision.

2. Analysis of operations of railways that have substantially reduced the cost of labor required in maintenance of way work.

   Progress report, presented as information .... page 259

3. Economics of labor in the laying of continuous welded rail, collaborating with Committee 31—Continuous Welded Rail.

   Final report, presented as information .... page 269

4. Labor economies in track and turnout construction or relocation by the panel method vs. conventional methods, for main and yard tracks.

   Study in progress, but no report.

5. Labor economies to be derived from modern bridge maintenance organization, using the latest equipment.

   Study in progress, but no report.

6. Economics of labor in tie renewals—cutting ties vs. removing whole ties.

   Final report, presented as information .... page 270

THE COMMITTEE ON ECONOMICS OF RAILWAY LABOR,
M. S. REID, *Chairman.*

AREA Bulletin 589, December 1964.

Report on Assignment 2

Analysis of Operations of Railways That Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work

N. H. Williams (chairman, subcommittee), A. D. Alderson, J. G. Begley, L. B. Cann, Jr., R. E. Clancy, L. E. Donovan, J. E. Eisemann, F. J. Farish, J. K. Gloster, G. L. Harris, R. B. Hayslip, T. L. Kanan, R. G. Maughan, G. E. McEntee, H. C. Minteer, R. W. Preisendefer, R. G. Simmons, J. T. Ward, H. E. Wilson, F. R. Woolford.

This report, submitted as information, describes the production-line method used in the dual laying of continuous welded rail on the Baltimore & Ohio Railroad. It is the 23rd report on "Analysis of Operations of Railways that Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work," which subject has been reassigned annually since 1935. The present report is based on a field inspection trip made by Committee 22, July 10, 1964, on the single-track main line of the B&O south of Frederick, Md. It outlines some of the intensive planning, close attention to details, and coordinated supervision necessary to make this method of rail laying economically justified. The equipment used represents an investment of $767,860.

Equipment List

	Purchase Price
2 rail trains	$180,200
Rail pusher and rail guide dolly	122,700
Cribber-adzer-creosoter	50,000
Multiple cribber	49,500
Tie-end sweeper	9,100
Wide-gage threader	39,150
Standard-gage threader	48,700
Gager-spiker	51,100
Rail anchor cart	4,800
Rail oiler	10,500
Rail cradles	8,900
Center-line marker	1,900
Scrap dump conveyor	11,700
2 tie drills	6,500
2 on-rail cranes with magnets	80,000
2 spike pullers	12,000
2 tie plug inserters	8,000
4 spike drivers	12,800
4 rail anchor applicator machines	28,000
Maintenance of equipment van	14,750
Pick-up truck	1,824
Bus	8,345
Crane truck	7,391
Total	$767,860

Planning

As soon as the rail-relay program has been finalized, detailed surveys of the relay sites are made. Field notes are taken recording the location of all physical roadway and track characteristics, including turnouts, bridges, grade crossings, etc. From these basic data schedules are prepared for the preparatory work that must be done in order to lay the welded rail economically. Also, any obstructions are removed from the center of the track and the ends of the ties to accommodate the rail-laying equipment.

During the preliminary survey a portable paint-spray striping machine is towed behind the supervisor's vehicle. This machine paints a fine line down the center line of the track which later is used as a reference line for the rail-laying operations.

Production Requirements

Every effort is made to have the track completely out of service to secure full utilization of the rail-laying equipment. Where this cannot be secured and the rail must be laid under traffic, close cooperation between the operating and maintenance of way departments is effected to provide the maximum on-track time possible.

Trains are "fleeted" so that a minimum of 3 hr of track occupancy at a time can be secured.

After arrival at the relay site, the rail-laying organization requires between 27 and 34 min to get the rail strings moving from the rail train, the machines set up for operation, and the production line in operation. Closure cuts in either the old jointed rails or in the welded strings are quickly made with an acetylene torch. Field drilling of the bolt holes is done with a power rail drill and the holes are reamed.

The manpower organization charts are based on having the track out of service for about 8 hr. Shorter working times force a change in the relation between manpower and daily production—for example, a 12-strings-per-day crew might lay only 8 strings in 5 hr on the track. The manpower for the dual rail-laying unit is set up on a daily basis—that is, the gang is adjusted according to the production expected for the day. For any anticipated daily production, laying either new or relay welded rail, the following manpower is required:

Estimated Production	*Trackmen*	*Operators*	*Total*
Four 1440-ft strings per day	19	15	34
Six 1440-ft strings per day	21	18	39
Eight 1440-ft string per day	27	18	45
Ten 1440-ft strings per day	31	20	51
Twelve 1440-ft strings per day	38	21	59

The supervisory force includes one general foreman and two track foremen for all production levels. Two mechanics maintain the equipment. Clean up of old materials is accomplished by three operators and four trackmen on a second shift, supervised by a general foreman and a track foreman. The entire field operation is directed by a system rail supervisor.

The estimated daily production depends on the amount of other work necessary at turnouts, road crossings, bridges, etc. When the anticipated production is low, the forces released from the production gang are scheduled to do the other work required. Division forces provide for delivery of supplies to the rail-laying unit, since they are more familiar with the sources of supply, access roads and other local conditions. They also take care of road crossings and guard rails on bridges and in tunnels. The machines are equipped with fuel tanks of sufficient capacity for one full day's operation.

The manpower requirements for various production levels, as furnished by the B&O, are detailed in Table 1. The actual manpower requirements for a production level of 12 strings per day are set forth in Table 2.

(Text continued on page 267)

Table 1

The Baltimore and Ohio Railroad Company

Continuous Welded Rail Laying Operation

Manpower Requirements

*Strings of 1440' welded rail

Operation	4 Rails/Day*		6 Rails/Day*		8 Rails/Day*		10 Rails/Day*		12 Rails/Day*	
	Track Men	Machine Oper.	Track Men	Machine Oper.	Track Men	Machine Oper.	Track Men	Machine Oper.	Track Men	Machine Oper.
1. Unload spikes, tie plugs, creosote, anchors, etc.	1	-	1	-	1	-	1	-	1	-
*2. Unload tie plates (with crane)	-	1	-	1	-	1	-	1	-	1
*3. Distribute new tie plates from piles to end of each tie.	1	-	1	-	2	-	2	-	2	-
4. Unload cradles and rail.	1	1	1	1	1	1	1	1	1	1
5. Position cradles	1	-	1	-	1	-	1	-	1	-
6. Adjust rail on cradles with bar	1	-	1	-	1	-	1	-	1	-
7. Remove old rail anchors	1	-	1	-	2	-	2	-	2	-
*8. Move tie plates from end of tie to center of 27" gage.	1	-	1	-	2	-	2	-	2	-
9. Cut rail with rail saw as required	-	As required, handled by closest operator from another machine in line								
10. Pull spikes										
a. Manually at joints	1	-	1	-	1	-	1	-	2	-
b. Mechanized	-	2	-	4	-	4	-	4	1	4
11. Pick up scrap spikes and anchors	1	-	1	-	2	-	2	-	2	-
12. Sweep tie ends	-	Automatic Machine. No manpower required.								

Table 1 (Continued)

The Baltimore and Ohio Railroad Company

Continuous Welded Rail Laying Operation

Manpower Requirements

*Strings of 1440' welded rail

Operation	4 Rails/Day*		6 Rails/Day*		8 Rails/Day*		10 Rails/Day*		12 Rails/Day*	
	Track: Men	Machine Oper.	Track: Men	Machine Oper.	Track: Men	Machine Oper.	Track: Men	Machine Oper.	Track: Men	Machine Oper.
13. Wide gage old rail	-	1	-	1	-	1	-	1	-	1
14. Throw out old tie plates (to 27" center if reused)	2	-	2	-	2	-	3	-	3	-
15. Countersink broken spikes	-	-	Combines with manpower in Item #14					-	-	-
16. Set and drive tie plugs (Mechanized)	-	2	-	2	-	2	-	2	2	2
17. Crib, adze & creosote	-	1	-	1	-	1	-	1	-	1
18. Position & gage tie plates	2	-	2	-	3	-	3	-	4	-
19. Standard gage new rail and drive line spikes	1	1	1	1	1	1	1	1	1	1
20. Distribute spikes	1	-	1	-	1	-	2	-	2	-
21. Gage rail with gaging spiker	-	1	-	1	-	1	-	1	-	1
22. Drill ties	-	1	-	2	-	2	-	2	-	2
23. Set spikes	2	-	3	-	4	-	5	-	6	-
24. Drive spikes (mechanized)	-	2	-	2	-	2	-	4	-	4
25. Distribute anchors	1	-	1	-	1	-	1	-	1	-

Table 1 (Continued)

The Baltimore and Ohio Railroad Company

Continuous Welded Rail Laying Operation

Manpower Requirements

	*Strings of 1440' welded rail									
	4 Rails/Day*		6 Rails/Day*		8 Rails/Day*		10 Rails/Day*		12 Rails/Day*	
Operation	Track Men	Machine Oper.	Track Men	Machine Oper.	Track Men	Machine Oper.	Track Men	Machine Oper.	Track Men	Machine Oper.
26. Position anchors under rail	1	-	2	-	2	-	3	-	4	-
27. Secure anchors (Mechanized)	-	2	-	2	-	2	-	2	-	3
Total men required:										
A. Using new tie plates	19	15	21	18	27	18	31	20	38	21
B. Re-using existing tie plates	17	14	19	17	23	17	27	19	34	20

* Not applicable when existing tie plates removed at job are re-used at same job site.

Note: This schedule applicable only to "out-of-service" track.

Table 2

The Baltimore and Ohio Railroad Company

Continuous Welded Rail Laying Operation

Manpower Requirements

12 Strings of Welded Rail 1440' Long

Operation	Unit of Measure	Time* Per Unit (Seconds)	No. of Units	Total Time (Hours)	Equivalent Men**		Actual Men Required	
					Track Men	Machine Oper.	Track Men	Machine Oper.
1. Unload spikes, tie plugs, creosote, anchors, etc.	Constant manpower - All production levels				1.000	-	1	-
***2. Unload tie plates (with crane)	"	"	"		-	1.000	-	1
***3. Distribute new tie plates from piles to end of each tie	"	"	8-12	Rails/ Day	2.000	-	2	-
4. Unload cradles and rail	"	"			1.000	1.000	1	1
5. Position cradles	"	"			1.000	-	1	
6. Adjust rail on cradles with bar	"	"			1.000	-	1	-
7. Remove old rail anchors	Anchor	11.50	3888	12.42	1.774	-	2	-
***8. Move tie plates from end of tie to center of 27" gage	Tie Plate	5.75	9504	15.18	2.169	-	2	-
9. Cut rail with rail saw as required	As required-handled by closest operator from another machine in the line							
10. Pull spikes								
a. Manually at joints	Spike	20.70	1728	9.94	1.420	-	2	-
b. Mechanized	Spike	6.90	17280	33.12		4.731	1	4
11. Pick up scrap spikes and anchors.	Spike or Anchor	2.30	22896	14.63	2.090	-	2	-

Table 2 (Continued)

The Baltimore and Ohio Railroad Company

Continuous Welded Rail Laying Operation

Manpower Requirements

12 Strings of Welded Rail 1440' Long

Operation	Unit of Measure	Time* Per Unit (Seconds)	No. of Units	Total Time (Hours)	Equivalent Men** Track Men	Equivalent Men** Machine Oper.	Actual Men Required Track Men	Actual Men Required Machine Oper.
12. Sweep tie ends	Automatic machine - no manpower required							
13. Wide gage old rail	Constant manpower-all production levels					1.000	-	-
14. Throw out old tie plates (to 27" center if re-used)	Tie plate	6.30	9504	16.62	2.376	-	3	-
15. Countersink broken spikes	Broken spike	9.20	432	1.10	.157	(With manpower in Item #14)		-
16. Set and drive tie plugs (Mechanized)	Tie Plug	3.45	19008	18.22	-	2.603	2	2
17. Crib, adze, and creosote	Constant manpower-all production levels					1.000	-	1
18. Position and gage tie plates	Tie plate	9.20	9504	24.29	3.470	-	4	-
19. Standard gage new rail and drive line spikes	Constant manpower - all production levels				1.000	1.000	1	1
20. Distribute spikes	Spike	2.30	16038	10.25	1.464	-	2	-
21. Gage rail with gaging spiker	Constant manpower-all production levels					1.000	-	1
22. Drill ties	Constant manpower-all production levels					1.000	-	2
23. Set spikes	Spike	9.20	16038	40.99	5.856	-	6	-
24. Drive spikes (mechanized)	Spike	4.60	16038	20.49	-	2.927	-	4

Table 2 (Continued)

The Baltimore and Ohio Railroad Company

Continuous Welded Rail Laying Operation

Manpower Requirements

12 Strings of Welded Rail 1440' Long

Operation	Unit of Measure	Time* Per Unit (Seconds)	No. of Units	Total Time (Hours)	Equivalent Men**		Actual Men Required	
					Track Men	Machine Oper.	Track Men	Machine Oper.
25. Distribute anchors	Anchor	2.30	9504	6.07	.867	-	1	-
26. Position anchors under rail	Anchor	9.20	9504	24.29	3.470	-	4	-
27. Secure anchors (mechanized)	Anchor	6.90	9504	18.22	-	2.603	-	3
Total actual men required: A. Using new tie plates							38	21
B. Re-using existing tie plates							34	20

* - Includes 15% allowance for non-productive time.

** - Number of "equivalent men" is determined by dividing total time required (in hours) for each of the above operators by the available working hours, per man, per 8 hour day. (Available working hours - 8 hours less 1 hour travel time, or 7 hours).

*** - Not applicable when existing tie plates removed at job site are re-used at same job site.

Note: This schedule applicable only to "out-of-service" track.

General Description of Operation

1. *Material Distribution.* All material and supplies required for one day's laying are distributed at the head end of the work train from material cars pushed ahead of the engine. An on-track crane placed between two of the cars and equipped with a magnet is used for unloading spikes and rail anchors. These fastenings are unloaded at predetermined intervals to expedite laying and minimize handling. Tie plates are unloaded by another magnet-equipped crane and placed in two piles for each 39 ft of track. Creosote, rail preservative, tie plugs and other supplies are unloaded by hand out of a box car. All materials and supplies are unloaded on the right side of the track so that released material, which is thrown to the left of the track, does not get mixed up with the new material.

2. *Communications.* The material-handling foreman, engine crew, pusher-car operator, system rail supervisor, mechanic and general foreman are equipped with portable two-way radios.

3. *Organization and Procedure.* Hats of different colors are worn by the various classifications of employees, as follows:

Orange	Supervisory forces
White	Foremen
Yellow	Machine Operators
Green	Mechanics
Blue	Trackmen

The welded rail to be laid is distributed out of 26 cars which are located behind the engine of the work train, and the rail is laid as the material and supplies are distributed.

The welded rail is unloaded, two rails at a time, in the center of the existing track so as to form a narrow-gage (28-in) track between the existing jointed rails which are moved out to form a wide-gage (93 in) track. The tie plates are removed, the ties plugged, adzed and creosoted, and the tie plates replaced while the rails are in these positions. The welded rails in the narrow-gage track are then moved out to standard gage and the released rail and material are loaded into the empty train and shipped to the welding plant. However, no rail shorter than 30 ft is welded.

Work Methods Observed

The 26 rail cars, including a center tie-down car, are each equipped with floodlights for use when the rail and other track material is picked up during the second shift. On the car next to the engine there is a gasoline-driven electric generator for supplying the electric current. These rail cars carry four tiers of welded rails, 10 strings per tier, which amounts to 57,600 ft of welded rail when the train is fully loaded. Each car has three rail supports equipped with individual rollers for each rail. The tie-down car has center supports with tie-down clips which clamp the rails to the supports. The end supports on this car have rollers.

Unloading the welded rail and loading the released rail is done with the aid of a rail-pusher car, with a flat car at each end, located at the rear of the work train. The rail pusher car is equipped with hydraulically operated rollers which support the rail while it is being unloaded or loaded. The end flat car has two rollers for threading the welded rail to the narrow gage when it is being unloaded and two others for guiding the wide-gage jointed rail when it is being loaded. This car also carries the cradles used for gaging the rail to the narrow gage when unloading.

To start the rail laying operation the work train spots the pusher car approximately two rail lengths beyond the starting point. Two strings of continuous welded rail are winched from the rail-carrying cars to the rail pusher car with cables. The pusher car then moves the rails through the guide dolly mounted on the end flat car down onto the track where the rail ends are secured. Skids are attached to the rail ends to prevent their snagging as the rail moves over the ties. Then, as the work train locomotive pulls the train away, the pusher-car operator permits the rails to idle through the pusher assembly. As the work train moves slowly, trackmen place the narrow gage (28-in) rail cradles on every tenth tie, centering them on the previously painted center line. After 500 ft of rail has been unloaded, the train is stopped, so that the rail pusher can be used in making the joints, and certain equipment is transferred from standard-gage wheels to narrow-gage wheels. After joining the lines of previously laid continuous welded rail to that just partially unloaded, the rail laying is started. The rail train then continues to unload rail until it becomes necessary to connect the trailing ends of the first two strings of rail to the next two strings. This is done on the work car behind the pusher car, using the winch line that is part of the pusher-car equipment. The foreman and the two trackmen who place the cradles make these connections. As the train moves along unloading the rail, the crane operators and trackmen under the supervision of a foreman unload the spikes, rail anchors, tie plugs and creosote from the head end of the train.

The organization, equipment and work performed representative of the work being done on the day the work was inspected, is given in sequence below:

Equipment	*Machine Operators*	*Trackmen*	*Remarks*
1 crane with magnet*	1	2	Unload spikes, anchors, tie plugs and creosote.
1 rail pusher and rail guide dolly	1		
		1	Unload rail cradles.
	----------	1	Place rail cradles on painted center line.
	----------	2	Remove rail anchors.
2 spike pullers	4	----------	Pull spikes. Joint spikes are pulled manually.
1 scrap dump conveyor	----------	2	Pick up released material.
1 tie end sweeper	----------	----------	Automatic machine—no manpower used.
1 wide gage threader	1	2	Remove tie plates and place for reuse.
2 tie plugging machines	2	----------	Works from narrow-gage track.
1 multiple cribber	1	----------	Deepen cribs for rail anchor application.
1 cribber–adzer–creosoter	1	3	Place and gage tie plates from base of narrow-gage rail.
		1	Release cradles.
standard gage threader	2	----------	Hydraulic unit lines gage side, and gage spikes every 6th tie.
		2	Pick up and load rail cradles.
rail anchor cart	----------	1	Distribute 4 spikes per tie.
gager–spiker	2	----------	Gage spike both rails every 6th tie.
2 tie drills	2	----------	Drill all spike holes.
		3	Set spikes—shift tie plates when necessary.
2 spike driving machines	2	----------	Spike up rail.
1 self-propelled anchor car	1	1	Unload rail anchors.
2 rail anchor applicators	2	2	Apply rail anchors.
1 spare rail anchor machine	1	1	Miscellaneous work behind.
	23	24	

*When new tie plates are used, second on-rail crane is placed in work train.

In picking up the old jointed rail, the first section is winched to the pusher car's hydraulically operated treads, and the train stands still while the pusher car pulls the two sections of jointed rail onto the rail train. While still bolted, this rail is cut into strings, 500 to 800 ft long, to make loading easier. The first string is joined to the second, the second to the third and so on as the loading proceeds at a rate of about 47 ft per min until all strings released on the previous day's work have been loaded. This requires about 90 min of on-track time.

While the pusher car is loading the old rail, the work train with the magnet-equipped crane picks up the released spikes, anchors and plates.

The rail-laying machines are transported on special flat cars, positioned in the same order as when used in laying rail. A portable ramp is used for unloading the equipment. For loading, a winch is used for pulling the equipment up the portable ramp.

The men are transported to and from the job by bus and have lunch at the site of the work. On the average it requires approximately one week to lay a train of welded rail, pick up the released material and complete the job.

CONCLUSION

There were the minor delays that are inherent in this type of operation. Whenever more help was required, however, operators and trackmen would "pitch in" to take care of whatever was required to keep the production line moving, which is evidence of the high morale of the organization.

The operation progressed smoothly and quickly. From conversations with personnel on the job and observing the work, it is evident that all concerned are very proud of this dual rail laying gang and its capabilities.

The B&O, exemplifying private enterprise in its thinking, planning and never-ending search for new methods of doing maintenance of way work more economically, demonstrated to this committee that maintenance of way operations are practical on a production-line basis. It further proved that where heavy expenditures for equipment is economically justified and sold to railroad managements, track for faster, heavier loads can be provided at lower costs than ever before.

Report on Assignment 3

Economics of Labor in the Laying of Continuous Welded Rail

Collaborating with Committee 31—Continuous Welded Rail

J. R. Miller (chairman, subcommittee), M. B. Allen, J. F. Beaver, O. C. Benson, E. J. Brown, R. F. Bush, W. E. Chapman, S. A. Cooper, P. A. Cosgrove, C. G. Davis, W. M. S. Dunn, R. L. Fox, K. H. Hanger, W. H. Hoar, Claude Johnston, W. J. Jones, J. M. Lowry, J. A. Naylor, R. W. Preisendefer, D. E. Rudisill, B. J. Worley.

In gathering information for the following report, which is presented as information, your committee sent a questionnaire to 40 railroads. Replies were received from 14 roads, representing a total annual welded rail program of approximately 700 miles.

The new rail sections welded on these roads varied from 115 to 140 lb and the secondhand rail sections, 70- to 152-lb. The lengths of the strings varied from 1324 to 1512 ft, the determining factor being the lengths of the special trains used for transport.

The majority of the roads replying handled their rail trains in work-train service at speeds restricted to 30 to 40 mph. However, two roads reported handling their trains in revenue freight service with no special speed restrictions. The capacities of the rail trains varied from 22 to 54 full-length strings, the average being 35.

The cost to unload a rail train was nearly the same on all roads, averaging 29 man-hours per track mile. The cost to unload and distribute small track material was likewise consistent, averaging 60 man-hours per track mile.

The organization of the rail laying gang was practically the same in all cases, with some slight variations due to differences in the rail laying equipment used. The average size of gang was 78 men. Where rail was laid on existing plates and no adzing was done, two roads reported nearly a 50-percent decrease in gang size. Track occupancy time was nearly the same in all cases, the average being 5½ hr. Daily production was also nearly the same, averaging 0.9 mile per day. All roads reported that the labor necessary for laying secondhand rail was the same as for new rail.

CONCLUSIONS

There appears to be very little difference in labor costs for laying welded rail, regardless of the rail section or whether the rail is new or secondhand. There is a distinct advantage in laying the rail on the old plates, which is possible if the rail section is not to be changed or the ties are in such condition that adzing or gaging is not required. It would appear that, if any further labor economies are to be effected, more on-track time must be available and new, more efficient laying equipment must be developed.

No attempt was made to study the method of laying both rails simultaneously. However, as this method is developed, economic advantages may appear.

Your committee recommends that this assignment be discontinued until there are further developments.

Report on Assignment 6

Economics of Labor in Tie Renewals—Cutting Ties Vs. Removing Whole Ties

G. E. Warfel (chairman, subcommittee), M. B. Allen, O. C. Benson, J. L. Cann, R. H. Carpenter, R. E. Clancy, P. A. Cosgrove, C. G. Davis, J. M. Gilmore, V. C. Hanna, J. O. Holladay, R. H. Jordan, M. D. Kenyon, H. E. Kirby, T. D. Mason, R. G. Maughan, C. W. Owens, G. E. Scholze, H. W. Seeley, Jr., W. B. Stackhouse, F. R. Woolford.

Your committee submits the following final report on this subject, which is based on replies to a questionnaire.

The replies indicate that in tie renewal operations, the majority of the railways remove the old ties whole in preference to cutting the ties to be removed. Of the railways that remove the ties whole, 57 percent separate the tie renewal gang from the surfacing gang while 43 percent work the tie renewal unit as a part of the surfacing gang. Production ranges from 210 to 750 ties per day, with tie renewals per mile running from 350 to 1,400. The average number of man-hours required to renew one tie is 0.41. This figure includes neither the labor used for distributing the new ties nor the disposing of the old ties.

Of the railways that use the tie cutting method in renewing ties, 78 percent separate the tie gang from the surfacing gang and 22 percent work the tie insertion unit as a part of surfacing gang. Production ranges from 250 to 500 ties per day. Tie renewals per mile range from 141 to 750. The average number of man-hours required to renew one tie is 0.44. This figure includes neither the labor used for distributing the new ties nor the disposing of the old ones.

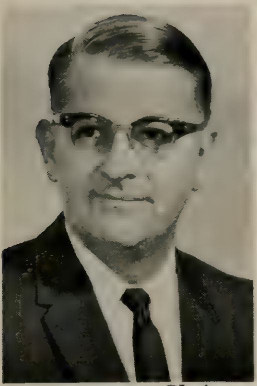
Some roads used both methods of removing old ties. But in such cases the whole-tie method is the primary operation, the tie-cutting method being used where heavy plate cutting exists. If the cutting method is used, the opportunity of disposing of the old ties by giving them away or selling them to customers or adjacent land owners is lost.

There does not seem to be any great difference in the cost of piling and burning the old ties, whether or not they were all in one piece. The cost of piling and burning ties ranges from 0.01 to 0.16 man-hour per tie. Where it is necessary to dispose of the old ties either by work train or by truck, the cost of disposal ranges from 0.07 to 0.15 man-hour per tie.

One railroad which removes ties by the cutting method, reported as follows:

> "Ties are stacked and burned when not removed from the right-of-way by adjacent property owners. In the areas of heaviest replacement, a tie destroyer is used to grind the ties. The ground material is discharged to the side of the right-of-way. Of the 355,000 crossties to be renewed in main tracks this year, approximately 30 percent will be disposed of by use of the tie destroyer. Utilizing the tie destroyer, the disposal cost is $0.15 per tie, or $0.28 per tie if the cost of the machine is included."

Report of Committee 27—Maintenance of Way Work Equipment



R. W. Bailey, ***Chairman***
R. M. Johnson,
Vice Chairman
J. O. Elliott, ***Secretary***
S. E. Tracy
Emil Eskengren
C. F. Hunt
J. W. Winger

H. A. Thyng
H. F. Longhelt
F. H. Smith
R. M. Baldock
C. A. Beemer, Jr.
R. E. Berrgren
L. J. Calloway
R. O. Cassini
L. E. Conner
D. E. Cowell
J. W. Cummings
A. C. Danks, Jr.
K. J. DeCamp
James Desko
V. L. Emal
E. H. Fisher
G. W. Guinn, Jr.
H. D. Hahn
W. T. Hammond
Haynie Hornbuckle
R. A. Hostetter
N. W. Hutchison
J. E. Inman
W. R. Jacobs
R. K. Johnson (E)
H. D. Jordan

M. E. Kerns
W. F. Kohl
W. E. Kropp
Jack Largent (E)
William Lenco
C. F. Lewis
G. J. Lyon
C. F. Montague
A. W. Munt
V. W. Oswalt, Sr.
R. W. Patton
H. C. Pottsmith
R. S. Radspinner
T. R. Rigsby
J. W. Risk
G. E. Roberts
F. E. Short
M. M. Stansbury
J. E. Sunderland, Jr.
T. H. Taylor
J. P. Titus
C. R. Turner
Alfred Wisman, Jr.
W. W. Wynne
F. E. Yockey
G. L. Zipperian
Committee

(E) Member Emeritus.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 27.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Progress report, including recommendations submitted for approval .... page 274

   (a) Revision of Handbook of Instructions for Care and Operation of Maintenance of Way Equipment.

   The committee is studying additional machines and a proposed revision of the Handbook, but is not prepared to submit a report at this time.

2. Improvements to be made to existing work equipment.

   The committee is assembling the various improvements suggested for handling with manufacturers. Report will be submitted in the future.

3. Standardization of parts and accessories for work equipment.

   Assignment completed in 1963 and recommended for discontinuance.

4. Switch heaters and other devices or machines for removing snow from switches, collaborating with Committee 18.

   Information is being assembled; committee expects to report in 1965.

5. Automation of maintenance of way equipment.
   Final report, submitted as information .... page 274

6. Alternators and transistorized electrical systems for installation on work equipment.
   Final report, submitted as information .... page 281

7. Snow removal equipment.
   Final report, submitted as information .... page 284

8. Specifications for equipment purchase.
   The committee is assembling information. Report will be submitted in the future.

The Committee on Maintenance of Way Work Equipment,
R. W. Bailey, *Chairman.*

AREA Bulletin 589, December 1964.

Report on Assignment 1

Revision of Manual

R. M. Johnson (chairman, subcommittee), R. E. Berggren, L. E. Conner, W. F. Kohl, R. S. Radspinner, G. E. Roberts, F. E. Yockey, G. L. Zipperian.

Your committee submits for adoption the following recommendations with respect to Chapter 27 of the Manual:

Pages 27–3–1 to 27–3–13, incl.

PART 3—REPORTS AND RECORDS

Reapprove without change.

Report on Assignment 5

Automation of Maintenance of Way Equipment

J. W. Winger (chairman, subcommittee), R. M. Baldock, R. O. Cassini, N. W. Hutchison, J. E. Inman, H. D. Jordan, G. E. Roberts, M. M. Stansbury, J. P. Titus, F. E. Yockey.

Production Tampers Equipped with Automatic Jacking and Leveling Devices as an Integral Part of the Basic Tamper

The evolution of tamping and surfacing track in general has progressed from pick-fork hand methods through mechanical tamping and hand jacking to mechanical tamping and mechanical jacking. Until recently, the mechanical jacking was done with a separate machine, but it was only natural and practical that jacking and tamping should be combined for improved efficiency.

The purpose of this report is to familiarize potential users with the types of equipment available at present, and their specifications and operation. This report includes production tampers equipped with automatic jacking and leveling devices as integral parts of the basic tamper. This concept has come into actual production reality only in the past several years.

The future is certain to produce better machines and different methods; and to that end we should view the machines described herein and all future machines with the idea in mind of how they can be improved to obtain the most from them.

Four different machines have been studied for this report. They are identified as Types A, B, C and D. Additional machines will be described in future reports.

TYPE A

This is a vibratory squeeze-type production tamper. The chassis is of all-steel, welded construction with six longitudinal 3- by 10- by ¼-in channels, spring mounted on both axle assemblies, each assembly having 20-in heavy-duty cast-steel wheels. The wheel base is 8 ft. The overall dimensions of the tamper are: Length 25 ft 0 in, width 9 ft 0 in, height 9 ft 5 in. It weighs 34,000 lb, including the automatic jacks.

The power plant is a diesel engine 4–75, type 4045E, 115 hp at 1800 rpm, directly connected to a nominal 40-kva alternator with 150-percent overload capacity. The alternator in turn drives, through two belts, two hydraulic pumps. The alternator itself furnishes current to operate four heavy-duty vibrator motors which impart 3200 vibrations per minute to the tamping tools. The alternator capacity is sufficient to assure constant maintenance of the vibrations at high speed as the tools penetrate the ballast.

The hydraulic pumps furnish hydraulic pressure for all other operations of the tamping heads, for propulsion of the machine through a transmission providing four-wheel drive, and for operation of a turntable jack. This machine is equipped with four-wheel hydraulic brakes and a mechanical parking brake working on the drive shafts.

On a push-button panel board in front of operator's seat there are buttons for starting and stopping the main engine and the left and right vibrator motors and levers for selecting either or both tamping heads.

By moving a single lever on a small, portable, remote-control box located either right in front of the operator on the machine or in his hand while he is off the machine the operator can let the machine go through the entire working cycle. He can stop the machine at any instant of its cycle by releasing the lever. Also, he can move the machine forward by moving the lever in the opposite direction. To set the machine to work fully automatically, this lever has only to be moved in the proper direction and the machine will lift, tamp, go forward and stop over the next tie to repeat the cycle, completely automatically. A device called a tie indexer automatically propels and positions the machine so that the tamping tools at stand-still are at equal distance from the center of the tie to be tamped. This complete automation is a feature of the Type A machine, whether it is equipped with automatic jacks or not. In either case, the actual tamping cycle is automatic and each tie is tamped to the same degree of compaction.

Limit switches manually set on each tamping head determine the depth of penetration of the tamping tools, and until this depth is reached the squeeze cylinders will not operate. The hydraulic pressure and the time of squeeze can be pre-set, and varied by manual controls if required.

The tamping heads automatically lock mechanically when fully raised. The hydraulic-turntable jack is pressurized in the "up" position except when in use.

All hydraulic lines are flexible hoses. All components of this machine are of U. S. manufacture with the exception of the vibrator motors.

The automatic-jacking attachment on this machine provides for complete control of the track lifting operation synchronized effectively with the tamping action. It consists mainly of an adjustable, transverse, heavy-duty, telescopic lifter frame attached to the main carrier in front of the vibrator heads. The distance from the rail being lifted to the rail being tamped is kept at a minimum. Lifting is done through two 18,000-lb-thrust jack cylinders, one on each side, setting firmly on large lifter shoes which distribute the thrust over large areas of the ballast. A self-locking clamp system mechanically locks the clamps around the ball of the rail. The automatic jacks have their own separate hydraulic system driven by the cover-end of a double pump.

When the tamping tools drop into the ballast, the clamps engage immediately and lifting commences. The lifting is completed during the time it takes for the tamping tools to penetrate the ballast. Squeezing of the tamping tools follows, and the lift is released only after the pre-selected squeeze pressure has been reached. Retraction of the tamping tools, clamps and lift cylinders occurs simultaneously. Since the lift takes place progressively at each tie, the height of lift at any one tie is comparatively small. The jacking cylinders are fast acting, so the rails are raised up to the required surface at approximately the beginning of the squeeze part of the cycle. The jacks maintain the surface required while the tools are squeezing.

The standard model of the Type A machine uses a frequency-modulated infrared-beam arrangement as the longitudinal reference to which the track is raised. There are two beams, one over each rail. The one over the grade rail is used as the longitudinal reference at any one time.

The beam is projected from a torque-motor-driven front buggy which travels continuously at a distance ahead of the tamper compatible with the track surface and the correction factor required—approximately 125 to 150 ft. The electronic sighting system permits operation from fixed elevations as well as running into fixed elevations with the projector buggy being stationary. The beam is received by a receiver located within the limits of the surfaced and tamped track at the back end of the tamper at a constant height over the grade rail. Actually, the beam is projected in an elliptical cone in a manner allowing for the angular variations, both vertical and horizontal, experienced in rough track and heavy curvature.

The receiver is set electrically to reject any light other than that emitted from the associated projector and to send a signal to the electrical control system whenever the level of intensity emitted by the projector drops below a given value. The intensity level is controlled by a metal shadowboard (physically located directly over the tie being tamped) which, when brought up by the lifting action, gradually reduces the infrared radiation from the projector to the predetermined intensity level, at which level the receiver provides a signal to stop the lift. The operator adjusts the lift by raising or lowering the metal shadow board, using a calibrated hand wheel located within easy reach.

While the grade rail is being lifted as dictated by the height of the shadowboard, the cross level is corrected by a vacuum-driven gyro and photoelectric cell device connected to the shadowboard which indicates the height for the cross-level rail with respect to the grade rail; in other words, the instant the grade rail is lifted higher than the opposite rail, the gyro will sense that the cross-level rail is "low," thus initiating a lift on the cross-level side until the gyro signals "level," which stops the lifting of the cross-level rail. By preadjusting the gyro, which is mounted on the shadowboard, to a desired superelevation, the gyro will stop an initiated lift with its "level" signal at the preadjusted superelevation, meaning that the machine will continue to produce a constant superelevation until a new adjustment is made through a calibrated hand wheel located on the opposite side from the lift-adjustment hand wheel. The calibration for superelevation is in increments of 1⁄16 in up to a maximum of 7½ in.

Both the grade-rail control wheel and the cross-level control wheel are geared to the shadowboard frame. By turning the grade-rail wheel, the entire shadowboard, located 11 ft 10 in ahead of the receiver, is raised and lowered without changing the cross level. On the other hand, by turning the cross-level wheel, the center shaft only of the shadowboard is raised or lowered while the height of the board directly over the grade rail remains unaltered.

With the forward buggy at a distance of 150 ft ahead of the tamper, the geometrical ratio is such that a 94-percent correction of track irregularities is achieved.

Performance Obtained

The production of the machine has been checked with and without the automatic jack attachment. Using the attachment makes no apparent difference in the overall speed of tamping. Depending on conditions of lift and ballast, the tamping cycle varies from 4 to 6 sec per tie, or 1½ min to 2¼ min per rail length. Over several 1-hr periods the distance surfaced varied between 800 and 1200 ft. The difference in tamping speed is accounted for by the adjustment for (a) tamping depth, (b) squeeze pressure and (c) squeeze speed. It was noticed that there was very little difference in tamping production whether the machine was set for full automatic or semi-automatic operation once the operator was familiar with the controls.

TYPE B

This is a vibratory, squeeze-type production tamper. It has a heavy-duty carriage consisting of welded steel members with rubber-cushioned axles and a heavy-duty differential. Powered by a 116-hp diesel operating at 1800 rpm, the tamper has a 4-wheel hydraulic drive with two fluid motors on each axle, maximum torque 25,000 in-lb, and valve-regulated speed. It has split-head controls, with independent hydraulic motors of 36 hp each at 2,000 psi, and has 16 vibratory squeeze-pressure tamping tools which are non-synchronized and fully hydraulic with pressure provided from the main system. The maximum compaction force between any two tools is 8000 psi with vibration amplitude of ⅜ in and frequencies up to 2800 cycles per min. The hydraulic system consists of three double pumps, solenoid mobile valves, 24-v d-c relief valves, four hydraulic motors with filters and flexible hoses and fittings throughout. The tamper is 26 ft long (excluding the buggy which is 10 ft long overall), 9 ft wide and weighs 36,000 lb (excluding the buggy, which weighs 1,250 lb). It has 4-wheel hydraulic brakes and a 4-wheel emergency mechanical brake system. Traveling speeds vary from 4 to 35 mph in both directions.

The surfacing device consists of a 4-wheel hydraulically driven buggy, powered by a gasoline engine, controlled remotely by the operator of the tamper. The buggy can be kept at a constant distance ahead of the machine or moved from location to location as desired by the operator. The buggy can be equipped with optional automatic detector feelers which fold out from the buggy to feel 20 ft ahead, automatically locate high spots and position the buggy.

Jacking is done by two 14-ton heavy-duty lifting cylinders. Two other cylinders each of 10,000 lb capacity are used for stabilizing and counteracting the bearing load on the front axle while lifting. Positive gripping clamps hold the rail head in advance of the tamping tools and the raise is maintained until an energized wire or a light beam is acuated. The rails are held by a knee lever at the point between the rail clamps and the tamping tools to assure correct gradient.

If the sighting is done by the energized wire system, a leveling wire is positioned over each rail in the same horizontal plane by a buggy pendulum. The leveling wires are under constant hydraulic tension and remain uniform as the tamper moves forward. The energized wires contact a sighting indicator as the desired raise is made, and this information is transferred to the cycling and control panel. The cross level is controlled by a mercury pendulum, and raising and tamping cycles are completely automatic. The controls are arranged and centrally located for efficient operation.

Information regarding the light-beam system was not available and will be described in subsequent reports.

TYPE C

This is an air-hydraulic-type production tamper. The chassis is of all-welded construction with the following dimensions: length—working 22 ft–6½ in, traveling 24 ft 6 in; width—working 11 ft 2½ in, traveling 9 ft 2½ in; height—9 ft 5¼ in. It is powered by a 6v-71 diesel engine driving a 365 cfm rotary compressor, hydraulic pump and 115-v generator for operation of controls. It is equipped with an hydraulic turntable and has a 4-wheel hydraulic drive through a 3-speed transmission. Tamping heads and spotting and jacking cylinders are controlled by solenoid-operated hydraulic valves. The complete cycle of tamper and beam is as follows:

1. The machine moves forward, and as the travel control is centered with the machine spotted over a tie (brakes applied) the cycle begins.
2. Rail clamps engage the rail under the head, and a signal from the surfacing device dictates the amount of raise to the solenoid valves that control the jacking cylinder at the raise rail.
3. An electrical cross-level device dictates the amount of raise to the other jacking cylinder and maintains a constant relationship with the jack cylinder at the raise rail. Direct-reading dials are used to crank in the raise as well as the elevation.
4. At the same time that the rail clamps engage and the jack cylinders begin to operate, both tamping heads begin to cycle. The operator adjusts for the number of insertions required, as well as the time duration of each insertion to ensure adequate tamping of the tie. At least one, and often two, insertions are made after the jacks have raised their full travel as dictated by the beam and cross-level device.
5. As soon as a cycle is completed, the machine automatically moves forward; the operator centers the travel control for spotting at the next tie and the cycle is repeated.

The machine is equipped with two-speed jacks. The travel of the jack cylinders is at high speed until the weight of the track is lifted, after which the travel speed shifts to the slower speed until the exact raise is accomplished. One insertion of the tamping bar is made after the jacking portion of the cycle is completed. Automatic corrections can be made at any time during the tamping cycle if either of the jacking cylinders should settle.

All controls for this machine are located at an operator's desk. All operations may be performed manually by push-button control as well as automatically. The use of two forward carts with a simple selector circuit to direct the surface to whichever cart is on the higher spot enables carrying a minimum raise. Sixteen heavy-duty air tamping tools hold the low raise possible with the surfacing device, even in heavy ballast or in less than desirable ballast conditions, so that the tamper itself can finish the low raise.

The electronic surfacing device consists of two 34-ft aluminum reference carts used in front of the machine. These two carts weigh approximately 168 lb and are so positioned that should the first cart locate just over a high spot, the second one will land on the high spot and carry the new grade. The raises are automatically made with respect to the higher of the two reference points in front of the machine, thus resulting in the lowest possible raise to establish a uniform grade.

A linear potentiometer is located at the hinge point between two 34 ft beams and between the rear beam and the tamper frame. The potentiometer measures the angularity between the corrected surface (that already tamped and under the rear axle of the tamper) and the forward carts on the unraised track. Resistance variations of the potentiometers are measured on a simple ohmmeter, using the wheatstone bridge principle and calibrated to the amount of raise required. This device is operated by a 12-v electrical system and is designed to operate automatically with the jack-tamping operation referred to previously. Adjustments for grade and cross level are made by adjusting rheostat switches controlled by solenoid switches and calibrated to conform to the conditions required. Controls are easily accessible to the operator, and tamping cycles and depths can be manually adjusted to vary according to the existing tie and ballast conditions.

TYPE D

The Type D machine consists essentially of:

(a) Standard tamper
(b) Tamper automatic workhead and indexing programmer
(c) Self-powered jacking and leveling carriage
(d) Light source carriage, radio controlled
(e) Light sensor rigging, applied to rear of tamping machine

Specifications

	Tamper	*Jacking Carriage*	*Light Source Carriage*
Length overall	16′ 2″	76″	66″
Width of chassis	8′ 0″	53″	72″
Width at workhead	10′ 6″		
Width jacks extended		11′ 6″	
Width jacks folded		10′ 6″	
Height over rail	8′ 4″	70″	65″
Weight	15,000 lb	3,800 lb	380 lb
Axle size	3″	1½″	1″
Wheels, eff. dia.	16″ cast steel	14″ pressed steel	6″ cast aluminum
Engine	453 diesel	VF4 gasoline	gasoline
Drive to wheels	Pwr. shft. trans.	None	Rev. elect. mtr.
Control	Push-button elec.	Electronic	Radio

Tamper: The automatic jacking equipment is most effectively used in conjunction with the electrically controlled models manufactured since 1962; however, it may also be applied to earlier models. Addition of the equipment requires no basic alteration to the tamper.

Programmer for tamper workhead and indexing control: This optional equipment is essentially a compact, readily adjustable, electric timing and counting device that duplicates the action of the best operator. It is easily adjusted as to (a) number of insertions, (b) depth of penetration of the tamping blades, and (c) height to which workheads are retracted in preparation for the next forward movement. Each workhead is independently programmed for maximum flexibility. The automatic action is instantly cancellable or, at the touch of a switch, is restricted to one or the other of the two workheads.

The programmer is entirely contained in a 4- by 8- by 10-in heavy weatherproof case. All electrical components are equipped with major circuit sections in plug-in modules for ease of servicing by substitution. When used in conjunction with this unit the programmer is, at the discretion of the operator, tied into the jacking equipment in a manner that automatically initiates the jacking cycle as forward (or reverse) indexing power is cut.

Jacking carriage: This is a self-contained, automatically controlled track lifting and leveling device that is pushed immediately ahead of the tamper where it jacks each tamping station to (a) a height determined by a three-point light-beam-related straight-line system and (b) to a cross level controlled by an accurate yet rugged electric level. The level is electrically adjustable, or offset, for curve superelevation by means of a direct-reading rotary control located at the operator's station. All power on the jack is derived from a pressure-compensated hydraulic pump driven by a VF4 air-cooled engine. Oil power is controlled by solenoid valves. These units operate in response to signals derived from the jacking height and cross-level transducer. These signals are built up and directed by simple, "solid-state" amplifiers and switches, largely contained in the 6- by 14- by 16-in weatherproof case of the jack control center. All major circuit sections are separated in the form of plug-in modules.

Jacking action is based on a pair of industrial-quality hydraulic cylinders each having a 3½-in effective diameter and 36-in maximum stroke, having a total lifting capacity of over 10 tons at an operating pressure of 2,000 psi. The jacks bear on a beam, located off the ends of the ties, and are fastened to the track, in preparation for raising, by a pair of fast-acting alloy steel "grab-anywhere" rail clamps contained in a free-floating strong-back that transfers no jacking strain to the carriage.

Light Source Carriage: This all-aluminum, self-contained, remotely controlled carriage serves a group of automotive-type lamps that are a major unit in Type D's three-element straight-line light-beam raising reference system. The electrical power 12v d-c, is derived from a lightweight 350-marine-type power plant whose output, in addition to feeding the lamps, powers the carriage driving system, which consists of an instantly reversible propelling motor, a slip clutch, a worm-gear speed reducer and a pair of rubber-faced rollers that contact the rim of two of the four carriage wheels. The carriage is positioned optionally either (a) high-to-high on the track by means of radio control or (b) held a fixed distance from the jack by taut-slack wire. The radio receiver and pocket-sized transmitter are of a rugged industrial type, all transistorized. The operating frequency of 26.135 MC and the low radiated power obviate the necessity for a license. Normal operation is restricted to a carriage position not more than 250 ft ahead of the jack.

Light sensor rigging: This equipment is mounted in place of the standard tamper bumper. It supports the light sensor, which is a major unit in the light-beam raising reference system, at a unit height of 60 in above the grade rail. The sensor embodies two vertically disposed groups of high-quality, stable, photo electriccells, all contained in a 2- by 9- by 18-in aluminum case supported in a universal mount with provisions for manual adjustment.

Report on Assignment 6

Alternators and Transistorized Electrical Systems for Installation on Work Equipment

H. A. Thyng (chairman, subcommittee), M. E. Kerns, D. E. Cowell, J. W. Cummings, V. L. Emal, E. H. Fisher, W. R. Jacobs, W. F. Kohl, C. F. Lewis, C. F. Montague, V. W. Oswalt, Sr., F. H. Smith.

Your committee submits the following final report on its study of alternators and transistorized electrical systems for installation on work equipment. At the present time such equipment is available from several well known manufacturers in various parts of the country.

It is recommended that knowledge of some of the basic procedures in servicing alternator-equipped units be acquired before it is decided on what types of work equipment the installation of an alternator is justified.

The important rules pertaining to the servicing of alternator-equipped units are as follows:

1. If a battery charger is to be used on a battery while it is still in a unit of equipment, both battery cables must be disconnected.
2. If a booster battery is to be used, like terminals must be connected.
3. When a new battery is installed, the positive and negative connections must be correctly made.
4. Before any electrical work is performed, both battery terminals must be disconnected.
5. The terminals of the alternator or regulator must not be shortened or grounded.
6. Before equipment is placed back in service after repairs have been made, all electrical leads must be double-checked for proper tightness.
7. It is important to remember that alternator-equipped units with dead batteries cannot be started by towing or pushing, because of the lack of voltage for the field buildup. The battery must be charged or jumped, or a new battery installed, before the engine can be cranked.

Generally, the same tools used for checking and adjusting a conventional generator can be used for an alternator.

Some of the advantages and disadvantages of alternators and transistorized electrical systems are as follows:

ALTERNATORS

Advantages

1. The cost of heavy-duty a-c alternators is about the same as for d-c generators.
2. Alternators are self-rectifying and regulating.
3. Can be used with transistor or fully transistorized regulators.
4. Have high-curb idle output.
5. Permit operating speeds up to 12,000 rpm.
6. Use continuous slip rings, and carry only light field current, which eliminate the commutator troubles experienced on d-c generators due to brush wear and high current.
7. Ratio between alternator and engine speeds can be higher for greater output at required speeds.
8. Extend life of batteries (reduce cycling).
9. Can be operated in either clockwise or counter-clockwise rotation, limiting stock requirement.
10. Have positive or negative ground.
11. Permit peak radio performance.
12. Permit full use of all accessories.

Disadvantages

1. High initial change-over cost.
2. Require specialized maintenance (mechanics) and equipment.

REGULATORS (GENERATOR)

Advantages

Transistorized Features

1. Vibrating-type voltage-sensing unit with transistors as the current amplifier.
2. Contacts handle only low current, which extends contact life since arcing is virtually eliminated.
3. Transistorized regulator makes possible a higher field current which improves overall performance.
4. Alternator design eliminates need for a current regulator below certain capacities.
5. No output current is carried through regulator because of the self-regulating feature of alternators.
6. The silicon diodes eliminate need for cut-out relays. Rotor field is energized by a field relay which is controlled by the ignition switch or pressure switch on diesel.

Transistor Regulator Features

1. Requires no servicing.
2. Unit has no moving mechanism.
3. Voltage can be adjusted externally; adjustments can be made without using a voltmeter.
4. Constant voltage—voltage setting not affected by temperature.
5. Mounting position or vibration will not affect performance.
6. Provides long-lasting settings.

Disadvantages

1. High reconversion cost.
2. Require specialized maintenance.

Note: Alternators in 12-v class are available in capacities up to 105 amp maximum output.

IGNITION DISTRIBUTOR—PULSE TYPE

Advantages

1. Has no breaker plate, contact points or condenser.
2. Requires no distributor maintenance.
3. Produces constant high voltage output to plugs at all speeds.
4. Increases spark plug life 3 to 5 times.
5. Provides greater fuel economy.
6. Improves starting at sub-zero temperatures.
7. Increases engine life.

Trans-Igniter

1. Uses no condenser.
2. Extends contact point life.
3. Increases spark plug life.
4. Provides constant high-voltage output to plugs at all speeds.
5. Provides greater fuel economy.
6. Improves starting at sub-zero temperatures.
7. Increases engine life.

Disadvantages

1. High cost of initial installation.
2. High cost of replacement parts.
3. Requires specialized maintenance training for mechanics.

Ignition Fully Transistorized

1. Still in experimental stage.
2. Requires specialized ignition timing (uses light beam).
3. Used chiefly for high speeds.
4. Questionable if adaptable for work equipment with low engine speeds.
5. Repair costs are high compared with standard ignition.
6. Initial costs are high.

While alternators and transistorized electrical systems have advantages on certain types of work equipment, the actual requirement should be determined by each railroad.

Report on Assignment 7

Snow Removal Equipment

H. F. Longhelt (chairman, subcommittee), C. A. Beemer, J. Desko, J. O. Elliott, R. K. Johnson, H. D. Jordan, W. E. Kropp, Wm. Lenco, A. W. Munt, H. C. Pottsmith, J. W. Risk, C. R. Turner, W. W. Wynne, G. L. Zipperian.

This is a final report, presented as information.

A comprehensive report on this assignment appears in Proceedings Vol. 48, 1947, pages 344 to 357. The following information supplements that report. Since the report of 1947 new types of equipment have been developed to aid in snow removal. Also, some of the equipment described in that report has become obsolete because of the dieselization of power.

While snow adversely affects all railroad operations, most railroad men would concur that snow and snow removal present more problems in terminals and yards than on line of road. Combating snow on line of road usually entails only plowing the tracks clear, whereas in most terminals entire removal of the snow from the yards is required.

This report does not cover the standard-type plows and spreaders which have been in long use on line of road, as there have been no substantial changes in this type of equipment. Instead, it attempts to list new equipment, improvements to existing equipment and use of machinery not specifically designed for snow removal.

SNOW BLOWERS

Type I

The self-propelled machine shown in Fig. 1 utilizes a centrifugal fan which blows air through a 3- by 72-in nozzle at a wind velocity of 160 mph. The fan is driven either by an air-cooled or diesel engine. The nozzle is adjusted hydraulically from top-of-rail elevation to 12 in above the top of rail. Steel cable fingers loosen the snow immediately ahead of the nozzle. This allows the snow to be blown clear of the track and dispersed into the atmosphere where wind currents carry it away for settlement over a larger area. This type of machine has been reported to have cleaned a 4-in snow fall from 20 switches in 25 min. The type of snow affects the results obtained with this machine. It works best in light powder-type snow. One advantage of this type of snow blower is that it removes the snow down to the ballast.

Type II

The type of blower shown in Fig. 2 combines the action of an auger with centrifugal action. The auger is 24 in. in diameter and rotates at a speed high enough to blow the snow by centrifugal force. The auger or rotor is driven by an air-cooled 4-cylinder, 60-hp gasoline engine. The blower weighs approximately 2,000 lb. It is 6 ft 4 in high and has a cutting width of 8 ft 6 in and a cutting height of 30 in. This blower is rated up to 7 tons of snow per minute and will cast snow a distance of 40 ft.

This type of blower is portable and can be handled by an on-track crane with a special boom or an off-track rubber-tired crane, and has been mounted on production tampers. When mounted on a crane it has the advantage of adjustable height and can be swung to either side of the center line of track to widen the cut. Also, when mounted on a crane the blower may be raised for traveling or swung around to operate in the reverse direction. In the latter case the amount of production time is increased as backtracking after a track has been cleared is eliminated. The Type II differs from Type I in that it will not remove snow below the top of rail.

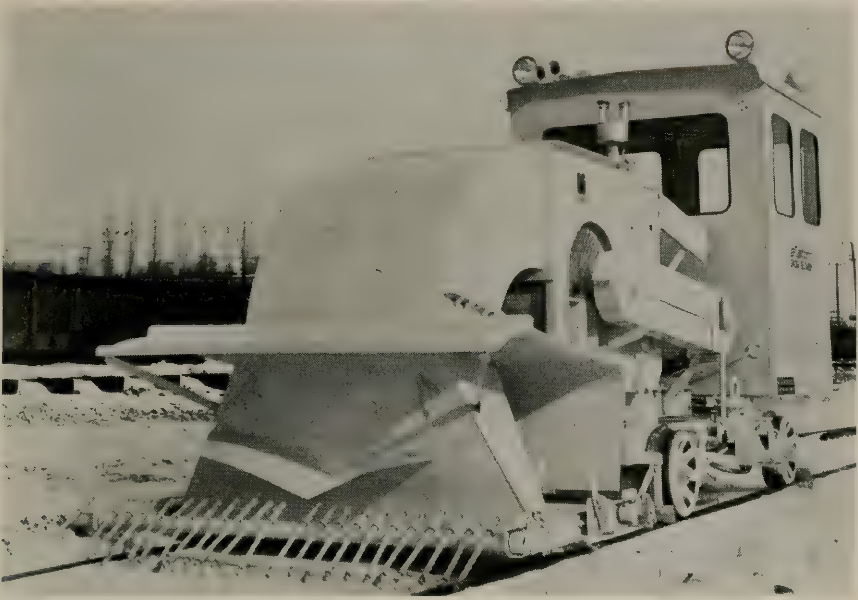


Fig. 1.

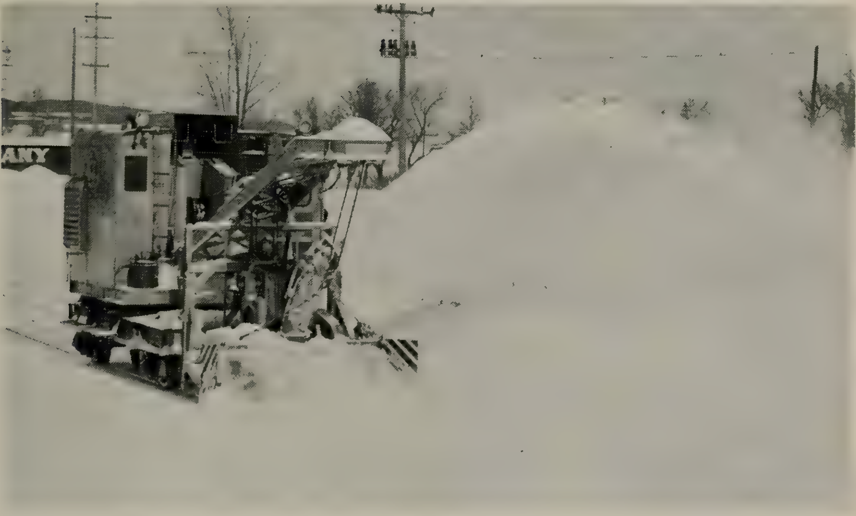


Fig. 2.

Type III

The blower shown in Fig. 3 is similar in principle to the type shown in Fig. 2. However, it is substantially heavier and is mounted on 16-in heavy-duty rail wheels. It can be handled by a weed burner, drainage car or some other on-track machine with enough weight to provide traction under adverse conditions.

This blower is powered by a 4-cylinder, air-cooled, 12-v-ignition, 56-hp engine. Drive for the 24-in-diameter rotor or auger is by means of a V-belt to a jack shaft and roller chain to the rotor. The rotor operates at 560 rpm, thereby creating enough centrifugal action to cast the snow, through a 10-in discharge chute, up to 40 ft from the center line of the track. The chute is manually adjusted for distance and is rotated through 360 deg by an hydraulic motor, which can be remote controlled from the cab of the machine handling the blower. The maximum discharge rate is 10 tons per min.

The overall height of the blower is 6 ft 5 in and the width of cut is 8 ft 6 in. When the blower is not in use the rotor is raised by two hydraulic cylinders. When in operation the weight of the rotor is supported on two chilled, cast, track shoes which ride the ball of the rail and are adjustable in height. The total weight of the blower is 4000 lb.

WEED BURNER—SNOW MELTER

Weed burners have been used for many years for melting snow from switches in yard track areas. Recently one manufacturer redesigned its standard self-propelled weed burner and now markets it as a snow melter. This machine, shown in Fig. 4, is almost identical to the weed burner with the exception that there is only one burner arm instead of five and the burning heads are mounted parallel to the rail. Three burner heads are mounted on each side of the burner arm in such a manner as to direct their flames at the inner base of the rail for maximum effectiveness.

It is essential that switches have proper drainage where the snow melter is used, as the water produced from melting snow will freeze and make the switch inoperative. In many cases where it is impossible to provide surface drainage of switches, dry wells are constructed at the headblock area, and these are thawed with the melter or weed burner at the same time the switch is cleaned. Weed burners and the snow melters have been effective equipment for snow removal in the past and will no doubt continue to be used in the future.

SNOW BROOM

There are a number of ballast regulators with ballast brooms on the market. Many railroads have used these machines in snow removal work. However, at least one manufacturer has designed a machine specifically for removing snow from switches, using the broom principle shown in Fig. 5. This is a self-propelled machine powered by a diesel engine. A rotating broom 40 in. in diameter and 8 ft long mounted on the front of the machine sweeps up the snow from the ties, and a positive-displacement screw conveyor carries the snow to the right, ejecting it beyond the tie-ends. The broom is composed of sections of train air hose. Power for the broom drive is mechanical through a twin-disc clutch. Both the broom and the screw conveyor are lifted hydraulically. A snowplow blade is mounted on the rear of the machine. The machine has a heated cab where all controls are located, including hydraulically controlled snow-discharge deflectors to place the snow fore or aft so switch stands will not be buried.

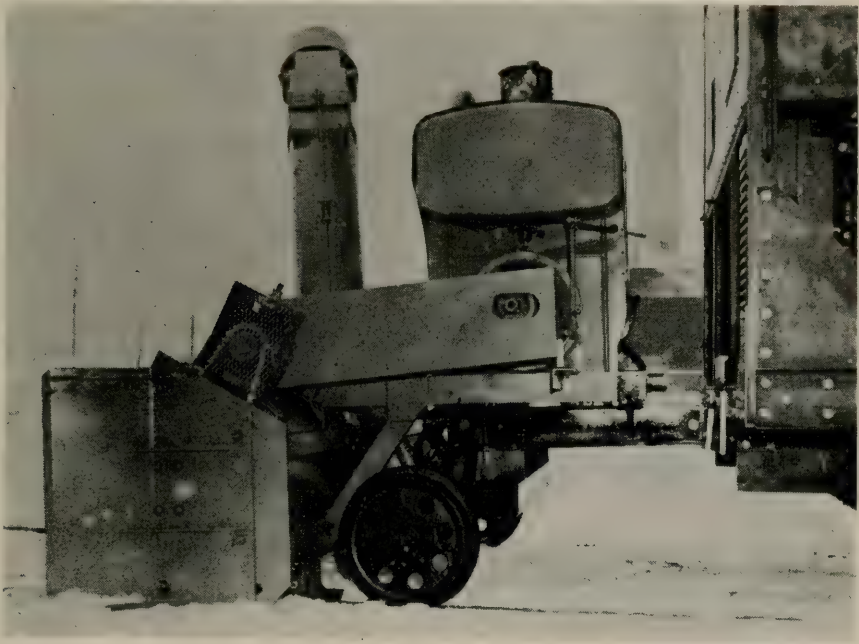
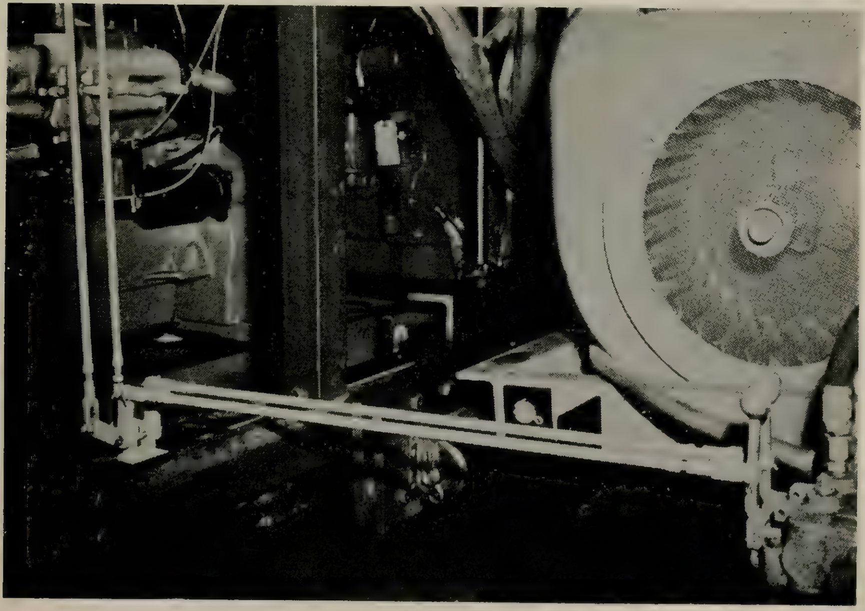


Fig. 3.



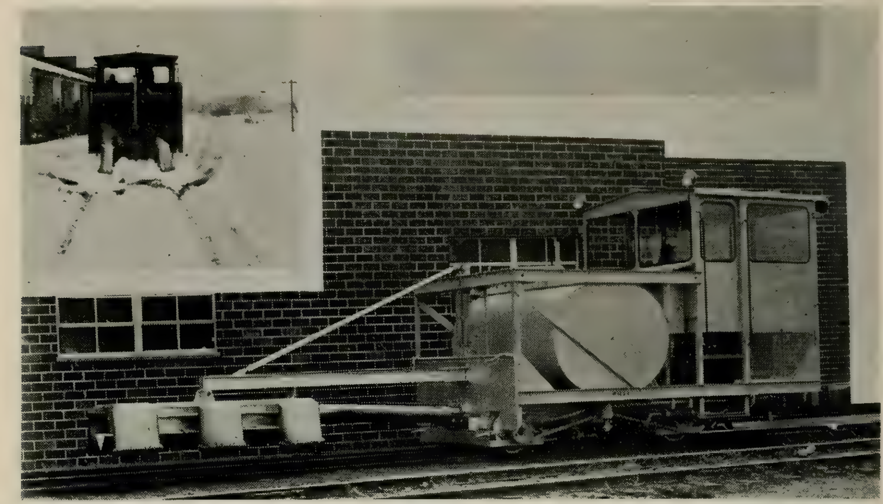


Fig. 4.

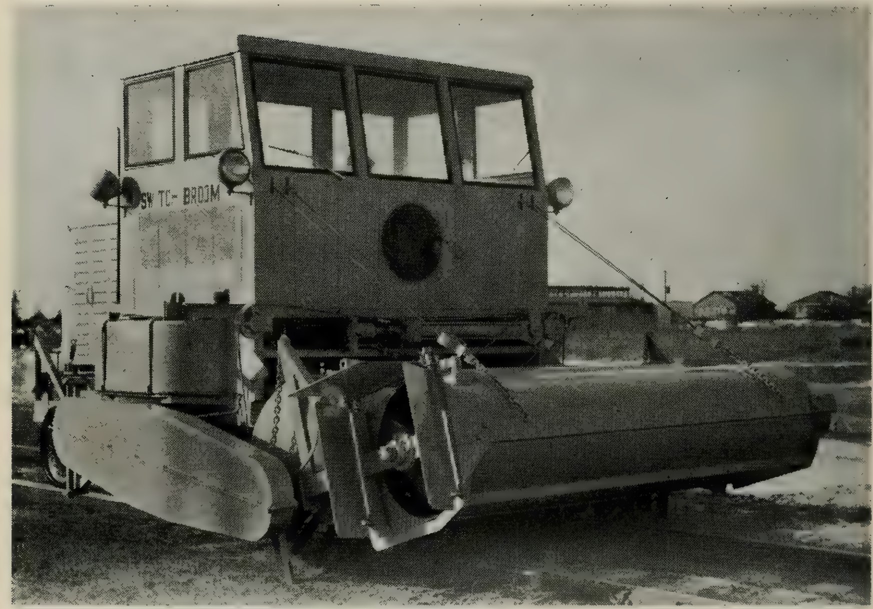


Fig. 5.

The overall length of the machine is 19 ft 6 in; overall width is 11 ft 7 in. It weighs 18,500 lb. The travel speed is 20 mph; working speed is up to 7 mph.

EQUIPMENT NOT SPECIFICALLY DESIGNED FOR SNOW REMOVAL

There are a great many machines used during snow storms and shortly thereafter to remove snow even though they are not specifically designed for snow removal. Here are a few:

1. Bulldozers and crawler-type front-end loaders
2. Cranes with clam buckets
3. Dump trucks with V and side plows
4. Motor graders
5. Ballast-drainage cars with special plows attached.
6. Various types of self-propelled conveyor-type yard cleaners
7. Industrial tractors with snow plows
8. Rubber-tired front-end loaders

In fact, any type of equipment that a supervisor can adapt for snow-removal work can be used to keep his railroad operating.

CONCLUSION

Although many new machines have been developed and others improved over the past decade to handle snow, the problem is still of the first magnitude. With the ever increasing cost of labor and greater automation in our yards, supervisors, engineers and suppliers must be alert and ingenious in developing new methods and machines for handling snow. Some ideas will prove to be impractical when tested, but each idea will bring us closer to a better solution of the problem.

U.S. BORAX OFFERS COMPLETE VEGETATION CONTROL SERVICE AND PRODUCTS THROUGHOUT THE COUNTRY

Our railroad herbicide specialists know your regional weed, soil, and weather conditions. They have an extremely wide selection of weed and brush killing chemicals. Now, with strategically located production facilities and the most efficient spray cars in railroading today, U.S. Borax is fully equipped to contract for any vegetation control program—and carry it out promptly, effectively and economically.

We would like an opportunity to prove it to you. Write today.

3456 Peterson Avenue, Chicago 45 • INdependence 3-6262

U.S. BORAX

Yes, Spike, you can't tie **UROX**® for weed control

Tie your weed control program to effective, low-cost UROX Railroad Weed Killers. A complete line—right for *your* weed problems, *your* climate conditions, *your* application methods. One application can last up to 18 months. Smaller, follow-up "booster" applications continue control inexpensively. Write or phone.

Allied Chemical

GENERAL CHEMICAL DIVISION
P.O. Box 353, Morristown, N.J.

SPEED SWING

MODEL 441

Developed and Built
for Railroad Maintenance

180° BOOM SWING

DOES ALL JOBS!

ROOTS AND LOADS TIES

LAYING WELDED RAIL

9' WIDE TRACK CLEANING BUCKET

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

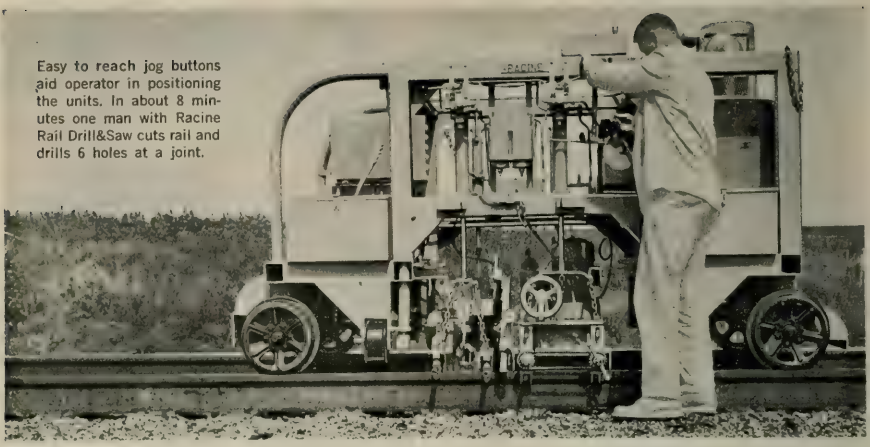
- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
- Back Filler Blade
- Pull Drag Bucket
- 4 Cu. Yd. Snow Bucket
- Pile Hammer

Optional Attachment
Flanged Wheels, Hydraulically Controlled

PETTIBONE MULLIKEN CORPORATION

RAILROAD PMCO DIVISION
141 W. JACKSON CHICAGO 4, ILL.

80 Years of Service
to the Railroad Industry



Easy to reach jog buttons aid operator in positioning the units. In about 8 minutes one man with Racine Rail Drill&Saw cuts rail and drills 6 holes at a joint.

UP TO 21 INSULATED JOINTS PER DAY

The Racine Rail Drill&Saw, equipped with a multiple 3 spindle drill and hydraulic feed reciprocating saw, is a dual-purpose, single operator machine for cutting-in insulated joints or cropping rail in track.

Up to 21 insulated joints per day in ribbon rail have been completed by a single machine, using the following sequence of operations:

(1) Saw rail and drill 6 holes.
(2) Expand joint with Templeton-Kenley Hydraulic Expander.
(3) Insert end post.
(4) Assemble angle bars (using electric impact wrench).

The 3 spindle drill unit may be pre-set to bore two or three holes on 5½″ to 7″ centers. Hole center adjustment is made by inserting solid spacer blocks, forming a "fixed" center drill head.

The saw unit is a new concept for reciprocating rail saws. Accurately controlled hydraulic feed pressure is used to cut rail consistently fast and straight. Blade cost is only a few cents per cut.

The machine is basically a self-propelled carriage and power plant for mounted saw and drill units. It is also available in various combinations of saw and drill units to suit your needs for in-track rail cropping operations. Electrical outlets on the machine give you plug-in power for impact wrench, drill bit grinder, work lights or other portable tools.

Write for more information today: Racine Hydraulics & Machinery, Inc., Dept. M94, Racine, Wisconsin. RR-150

RACINE

Unit Tamper

Portable Rail Drill

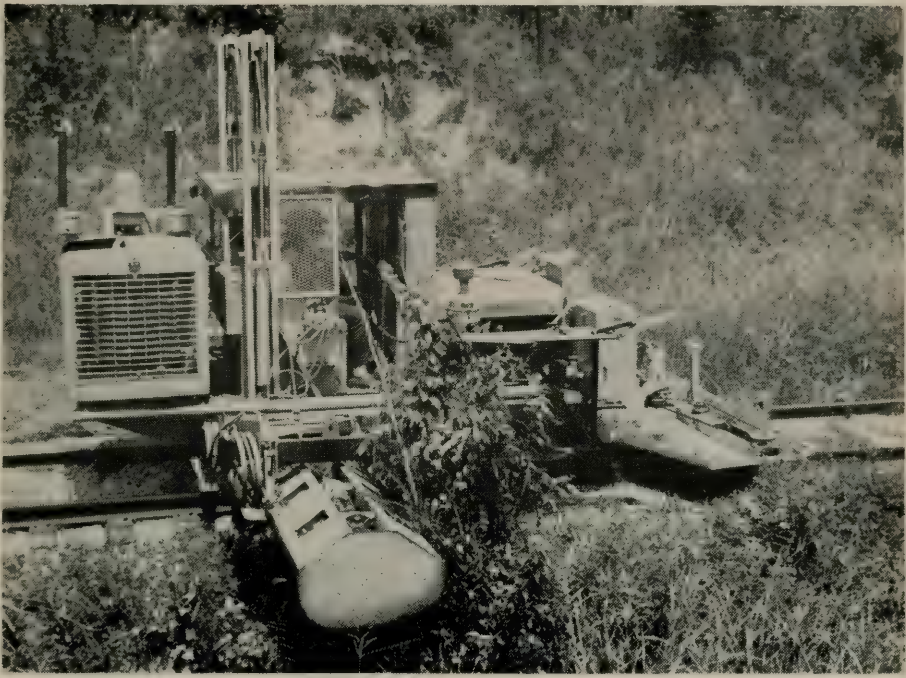
Portable Rail Saw

Anchor Applicator

Rail Drill&Saw

Production and Spot Tampers

KERSHAW Trackwork Machines



Weed And Brush Cutter (Track Patrol)
Designed, Tested, and Proven
on America's Railroads

KERSHAW
MANUFACTURING CO. INC
MONTGOMERY K ALABAMA

Trackwork Equipment Developed and Proven On the Job

Heavy Duty Ballast Regulator, Scarifier and Plow, Standard Ballast Regulator, Sacrifier and Plow, Track Broom, Super Jack-All, Standard Jack-All Kershaw Kribber, Two-Wheel Kribber, Tie Bed Sacrifier Tie Inseter, Track Undercutter-Skeletonizer, Ballast Cleaner, Crib-Adze, Mocar Crane, Track Crane and Tie Inserter, Utility Derrick, Two-Ton Rail Derrick, Tie Replacer, Dual Tie Saw, Track Liner, Snow Switch Cleaner, Weed and Brush Cutter (Track Patrol).

Extend Tie Life!

Hold Gage!

USE TIE PLATE *LOCK SPIKES*

One-piece Design

LOCK SPIKES hold tie plates firmly in place on cross-ties and bridge timbers.

LOCK SPIKES are quickly and easily driven, or removed, *with standard track tools.*

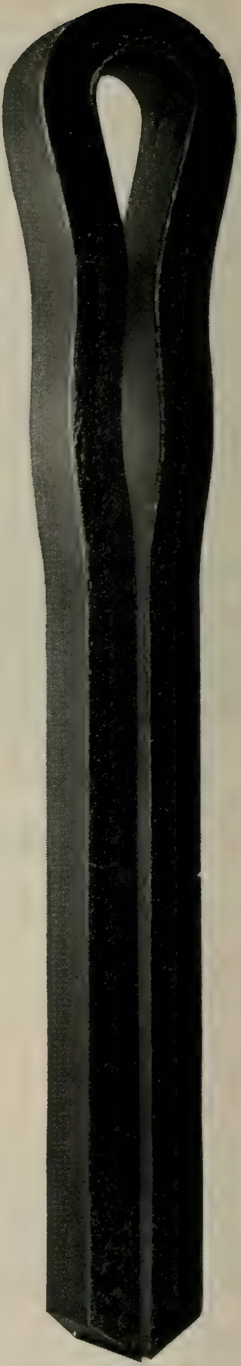
Driven to refusal, the spread shank is compressed by the walls of the hole. Tie plates are held against horizontal and vertical movement under spring pressure. Play between the spike and the hole is eliminated—abrasion and seating of tie plates is overcome.

LOCK SPIKES hold their position in the tie, and redriving to tighten the plate is not required. They provide a quiet and strengthened track.

Annual cost of ties and maintenance expense is reduced by extending the life of ties and holding gage. Here is one answer to conservation of materials and labor. Write for free folder.

BERNUTH, LEMBCKE CO., INC.

420 Lexington Avenue, New York 17, N. Y.



Actual Size

WHAT'S **NEW** IN YARD AUTOMATION

GRS, a steady contributor to the art of yard automation, now brings you two new "tools" which incorporate the latest developments in ultrasonics and locomotive remote control:

ULTRASONIC CAR PRESENCE DETECTOR

Solves the problem of distinguishing between long and short cars in the operation of switch detector track circuits.

Handles extra long cars automatically—while retaining the maximum humping rate—without extending the length of existing detector track circuits.

Uses the ultrasonic principle to detect presence of a car body—interlocks with detector track circuit to ensure fail-safe operation.

HUMP ENGINE SPEED CONTROL SYSTEM

Enables the selection of exact humping speed from the retarder tower—precisely maintained, instantly adjustable.

Eliminates locomotive creep-up during humping—speed is regulated more closely than is possible with manual control.

Applicable to any type of diesel-electric locomotive—especially to locomotives already equipped with GRS inductive cab signaling.

3270

CONTACT YOUR GRS REPRESENTATIVE FOR MORE INFORMATION

GENERAL RAILWAY SIGNAL COMPANY
A UNIT OF GENERAL SIGNAL CORPORATION

ROCHESTER 2 NEW YORK   NEW YORK 17 NEW YORK   CHICAGO 1 ILLINOIS   ST LOUIS 1 MISSOURI   MONTREAL 2 CANADA

RACOR PLANTS:
Buffalo · Chicago Heights · Los Angeles · Niagara Falls, Ontario, Canada · Pueblo · Superior.

★ **RACOR SALES AND ENGINEERING**
Chicago · Cleveland · Denver · Houston · Los Angeles · Louisville · New York · Philadelphia · Richmond · San Francisco St. Louis · St. Paul. In Canada: Dominion Brake Shoe Co., Ltd., Montreal, Quebec · Niagara Falls, Ontario · Winnipeg, Manitoba · Vancouver, B. C.

* **RACOR RESEARCH:**
Chicago · Mahwah, N. J.

with America's most complete line of special trackwork: For Railroads, Mines and Industries—A complete line of *frogs, switches* and *crossings* • *Trackwork for installation in paved areas* • *Manganese steel guard rails* • *Automatic switch stands* • *Samson switch points* • *Snow-Blowers* • *Switch point guards* • *Rail and flange lubricators* • *Tie pads* • *Racor studs* • *Dual spike setters* • *Dual spike drivers* • *Car retarders.*

with America's most complete trackwork manufacturing facilities: Coast to coast to serve your needs.

with America's most complete trackwork engineering service: This lies in making available to our customers Racor's engineering experience—*practical* experience from years of designing and manufacturing . . . *advanced* experience solving tomorrow's trackwork problems today in Racor research laboratories.

Why not let us help *you* with your trackwork problems?

A-1646
RACOR

RAILROAD PRODUCTS DIVISION
530 Fifth Avenue, New York 36, New York

AMERICAN Brake Shoe COMPANY

Get any coating job done... ANYWHERE with

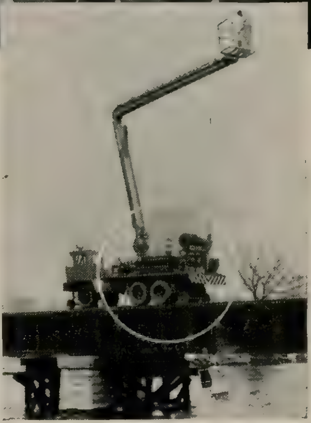
GRACO

HYDRA-SPRAY

The custom-built assembly shown above and to the right is an all-purpose rig designed to give *maximum* flexibility in coating and painting work. It was designed for field application of paints, lacquers, vinyls, cutback asphalts, creosotes, heavy oils and greases.

It uses the *economical* Graco Hydra-Spray Process, and proves once again, you get the job done faster and better with Graco than with any other coating system.

If speed of coating application, and material savings are important to you, write today for all the details of the Graco Hydra-Spray Process.



FREE! Graco Engineers are prepared to help you in the design of your paint and material spray assemblies. Your Graco Railway Representative will be glad to explain the many benefits of this service. Write or call him . . . *today!*

GRACO **RAILWAY DEPARTMENT**

GRAY COMPANY, INC.
MINNEAPOLIS 13, MINNESOTA

JOHN P. McADAMS, Eastern Sales Representative
2304 Wilson Boulevard, Arlington, Virginia

CHICAGO—(Broadview, Ill.)
R. D. Worley
3030 South 25th Ave.

CLEVELAND
M. H. Frank Company, Inc.
1202 Marshall Building

HOUSTON
Houston Railroad Supply Co.
1610 Dumble Street

PHILADELPHIA
The A. R. Kidd Co.
1036 Suburban Station Bldg.

LOUISVILLE
T. F. & H. H. Going
6308 Limewood Circle

ST. LOUIS
The Carriers Supply Company
818 Olive Street

NEW YORK—Newark, New Jersey
R. A. Corley
744 Broad Street

SAN FRANCISCO
The Barnes Supply Company
141 Eleventh Street

TWIN CITIES—St. Paul, Minn.
The Daniel L. O'Brien Supply Company
Endicott-On-Fourth Bldg.

WASHINGTON—Arlington, Va.
Southeastern Railway Supply, Inc.
2304 Wilson Blvd.

MONTREAL—Ontario, Canada
International Equipment Co., Ltd.
360 St. James Street West

Assure lower maintenance costs,
better performance with...

TEXACO

Petroleum Products and Systematic Engineering Service

TEXACO INC.
RAILWAY SALES DIVISION
135 East 42nd St., New York 17, N. Y.

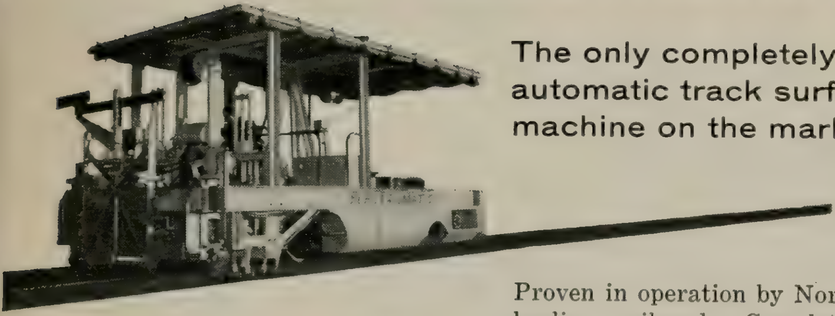
NEW YORK • CHICAGO • SAN FRANCISCO • ST. LOUIS • ST. PAUL • ATLANTA

THE DOUBLE U RAIL ANCHOR

ACHUFF RAILWAY SUPPLY CO.
ST. LOUIS, MO.

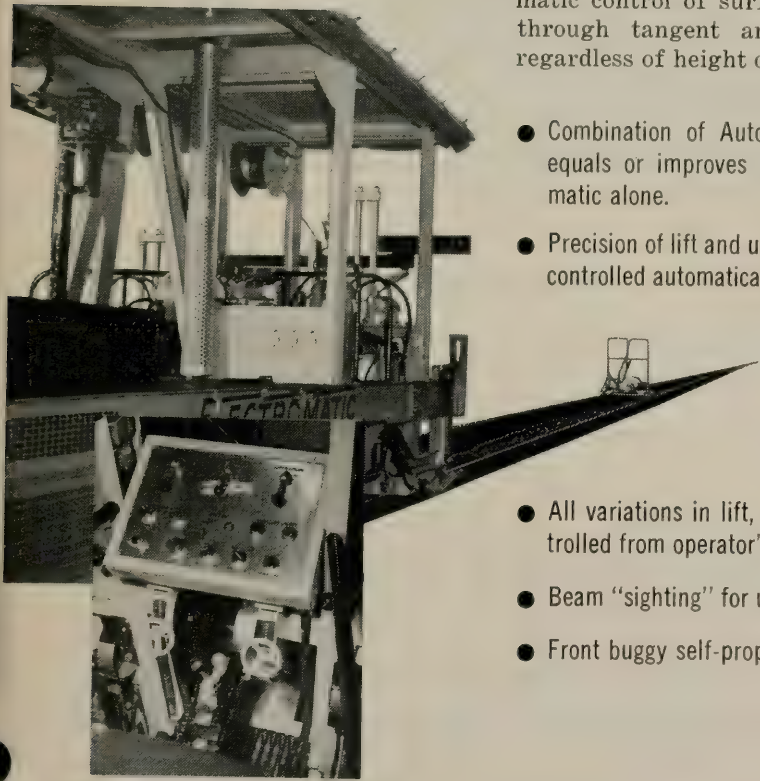
Tamper

AUTOJACK ELECTROMATIC



The only completely automatic track surfacing machine on the market

Proven in operation by North America's leading railroads. Complete and automatic control of surface and cross level through tangent and curve territory regardless of height of lift.



- Combination of Autojack and Electromatic equals or improves production of Electromatic alone.
- Precision of lift and uniformity of compaction controlled automatically.
- All variations in lift, level and run-out controlled from operator's panel.
- Beam "sighting" for utmost precision.
- Front buggy self-propelled ahead of tamper.

Tamper

TAMPER INC. 53 Court St., Plattsburgh, N.Y.

SALES AND SERVICE: 2147 University Avenue
St. Paul 14, Minnesota
Phone: 645-5055

IN CANADA 160 St. Joseph Blvd.,
Lachine (Montreal), P.Q.
Phone: 637-5531

Your enquiries for detailed information or brochures on Autojack Electromatic and other track machines are invited.

WOODINGS-VERONA TOOL WORKS
Pioneer Manufacturers
of
HIGH GRADE TRACK TOOLS
and
SPRING WASHERS FOR TRACK
Since 1873
VERONA, PA. CHICAGO, ILL.

WOODINGS FORGE & TOOL COMPANY
Makers
of
WOODINGS RAIL ANCHORS
VERONA, PA. CHICAGO, ILL.

Notes on
Railroad Location and Construction Procedures
from the School of Experience

By J. A. Given

A series of notes, comments, short-cut methods and "tricks of the trade" written by a railroad location engineer of many years of practical experience for the benefit of young engineers.

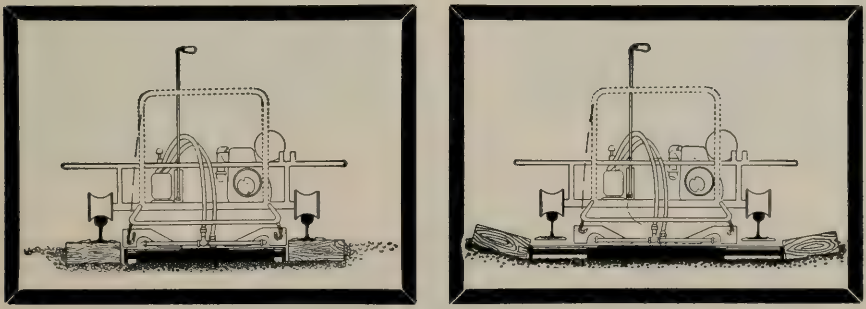
Price $0.50

AMERICAN RAILWAY ENGINEERING ASSOCIATION
59 East Van Buren Street
Chicago 5, Ill.

Model N U Tie Cutter

HERE IS THE WINNING TEAM

The Woolery NU Tie Cutter and the Woolery Tie-end Remover preserve the line and surface of the track and at the same time reduce the cost of tie renewals. Ties can be removed without trenching, jacking up track or adzing tops of rail-cut ties. With this team you simply cut both ends of tie, pry out center piece, insert in its place the tie-end remover and out go the tie ends pushed by the double acting, double ended hydraulic cylinder of the Tie-end remover.



FOR HIGHEST EFFICIENCY USE TWO TIE CUTTERS WITH ONE TIE-END REMOVER

WOOLERY MACHINE COMPANY
MINNEAPOLIS, MINN.

IMPROVED HIPOWER

A COMPLETE LINE
OF SPRING WASHERS

THE NATIONAL LOCK WASHER CO.
Newark N. J., U. S. A.

P. & M. PRODUCTS
- IMPROVED FAIR Rail Anchors

RAIL JOINT PRODUCTS
- Rajo Joints
- Insulated Joints
- Compromise Joints
- Fibre

MAINTENANCE EQUIPMENT PRODUCTS
- Meco Rail and Flange Lubricators
- Meco Rail Layers
- Meco Brush Cutters
- MACK Reversible Switch Point Protectors

PEERLESS EQUIPMENT PRODUCTS
- Draft Gears
- Rail Titan Batteries

IN CANADA:
The P. & M. Company Ltd

552AB

PRODUCTS OF PROGRESS

POOR & COMPANY
Railway Products Division 80 E. Jackson Blvd., Chicago 4, Ill.

KEEPING TRACK
IS OUR BUSINESS!

NCG®

- RAIL WELDING SYSTEMS
- WELDED RAIL LAYING SYSTEM
- WELDED RAIL TRANSPORT

- ABRASIVE RAIL CUTTER
- 6-HOLE RAIL DRILL
- LINK-BELT SPEEDER CRANES AND DIESEL PILE HAMMERS

© 1964, CHEMETRON CORPORATION

RAILROAD EQUIPMENT DEPARTMENT

NATIONAL CYLINDER GAS
Division of CHEMETRON *Corporation*
840 NORTH MICHIGAN AVENUE · CHICAGO, ILLINOIS 60611

Hubbard Super Service Alloy Spring Washers
Hubbard Super Steel Alloy Spring Washers
Hubbard Track Tools

Hubbard Tool Division
UNIT RAIL ANCHOR CORPORATION
New York Pittsburgh Chicago

Unit Rail Anchor

UNIT RAIL ANCHOR DIVISION
UNIT RAIL ANCHOR CORPORATION
NEW YORK PITTSBURGH CHICAGO

P. O. Box 10378
Area Code 305
LOgan 6-7922

GREENHEART, INC.
1431 N. E. 26th Street
FORT LAUDERDALE, FLORIDA

President—John L. McEwen—Quarter Century Experience

IMPORTERS:

GREENHEART—3300F Piles, Lumber, Timbers Long Length
MORA EXCELSA—Lumber and Timbers
MANBARKLAK—Piles
ANGELIQUE (Basra Locus)—Piles, Lumber and Timbers
and other Woods from
Burma, Siam, Australia, Africa and South America

Data furnished on request

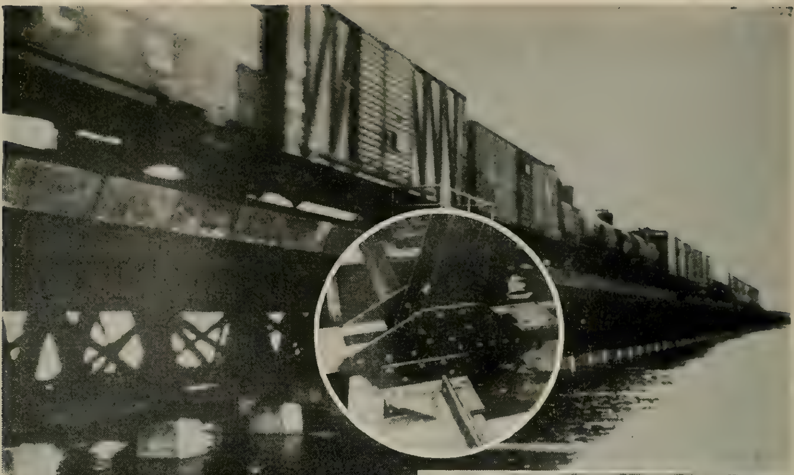
A New Symbol that means Job-Verified Equipment for the Railroad Industry

This new, big **"J"** is the symbol of progress on the newest, most thoroughly engineered and efficient automated track maintainers ever developed—for instance . . .

Jackson's new GandyDancer® and Track Maintainer® Team that will "sight" track, raise and level it and tamp . . . all electronically controlled, all operated by one man. This is another continuing example of Jackson's efforts to provide track maintenance equipment with unsurpassed productivity and quality.

Write for complete, detailed information on this newest track maintainer as well as the complete line of Jackson's Job-Verified equipment for the railroad industry.

JACKSON VIBRATORS, INC.
Ludington, Michigan



The railroad bridge pictured has been protected satisfactorily with Brooks Protective Coating for over five years. The steel in the structure is subjected to atmospheric contamination, water action and winter snow and ice.

BROOKS

PROTECTIVE COATING FOR BRIDGES AND BUILDINGS

Corrugated metal buildings are subjected to corrosion and in some cases, severe corrosive conditions exist. Brooks Protective Coating will resist corrosion which causes deterioration to metal surfaces.

Easily applied by spray or brush.

Talk it over with the BROOKS OIL man near you!

The BROOKS OIL Company

Established 1876

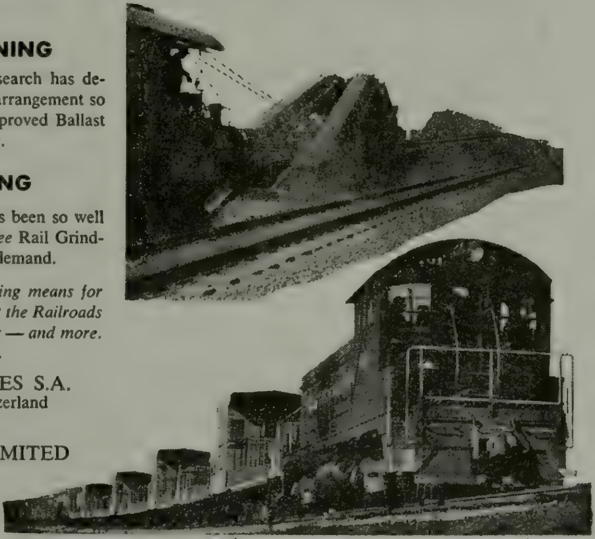
General offices and U.S. plant: 3304 East 87th Street • Cleveland 27, Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton, Ontario

The Brooks Oil International Company: Exporters

PROGRESS REPORT

SPENO

Here are the up-to-date facts on the SPENO Ballast Cleaning and the SPENO Rail Grinding Services.



BALLAST CLEANING

SPENO Engineering and Research has developed a superior screening arrangement so that we are now using an improved Ballast Cleaner with greater efficiency.

RAIL GRINDING

Our Rail Grinding Service has been so well received — we now have *Three* Rail Grinding Trains to take care of the demand.

SPENO is constantly developing means for better service to make sure that the Railroads receive everything they pay for — and more.

Outside North American continent:

SPEMA RAIL SERVICES S.A.
Grand-Pont 2, Lausanne, Switzerland

Canadian Sales Representatives:

THE HOLDEN CO. LIMITED
614 St. James St., West
Montreal, Canada

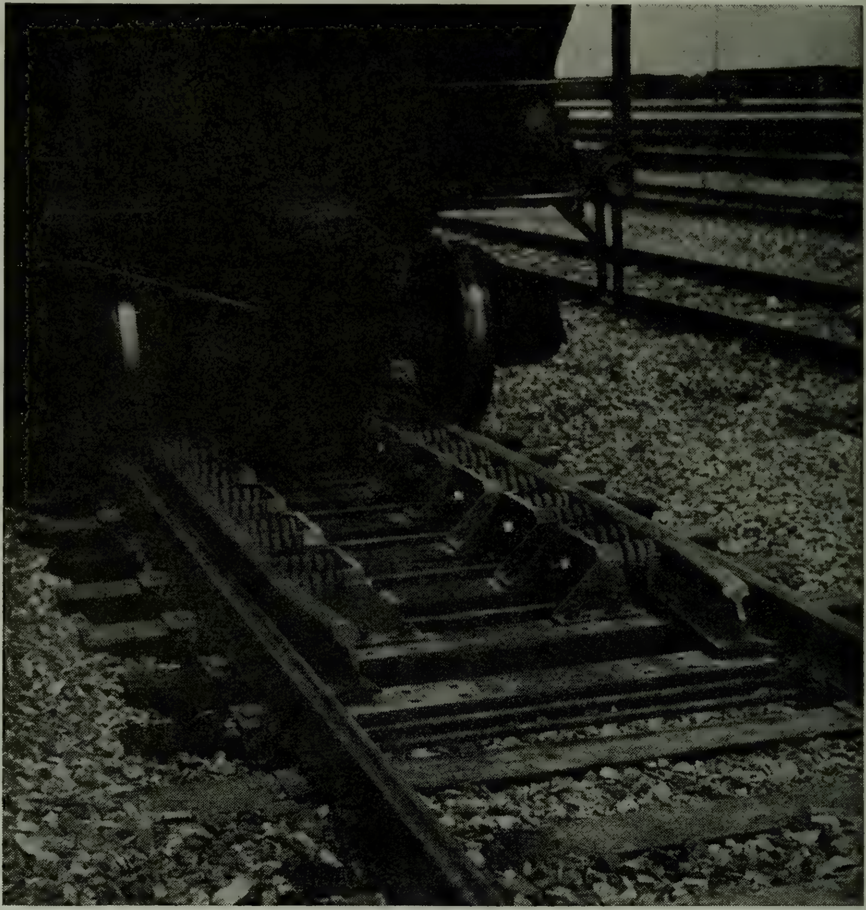
Just Ask the Railroads That have used us!

GEARED TO PROGRESS
P R I
MEMBER

FRANK SPENO RAILROAD BALLAST CLEANING CO., INC.

Clark Street
East Syracuse, N. Y.

306 North Cayuga St.
Ithaca, N. Y.



THE TRASCO CAR RETARDER

HUNDREDS IN SERVICE
IN CLASS YARD TRACK

TRACK SPECIALTIES COMPANY
P.O. BOX 729 WESTPORT, CONNECTICUT

American Railway Engineering Association—Bulletin

Bulletin 590
Proceedings Vol. 66*

January 1965

REPORTS OF COMMITTEES

15—Iron and Steel Structures ---------------------- 291
7—Wood Bridges and Trestles ------------------- 299
8—Masonry -- 305
24—Cooperative Relations with Universities ---------- 325
18—Electricity ------------------------------------ 339

The reports in this issue of the Bulletin will be presented to the 1965 Annual Meeting of the Association at McCormick Place, Chicago, March 23–25. Comments and discussion with respect to any of the reports are solicited, and should be addressed to the chairman of the committee involved, in writing in advance of the Meeting, or from the floor during the Meeting.

---

* The contents of this Bulletin and the other Bulletins of the Association from Bulletin 587, September–October 1964, to and including Bulletin 593, June–July 1965 (except Bulletin 592, March 1965), will constitute the Annual Proceedings of the Association, Vol. 66.

Copyright 1965, by American Railway Engineering Association

BOARD OF DIRECTION

1964–1965

President

T. F. Burris, Special Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

Vice Presidents

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.
J. M. Trissal, Vice President, Illinois Central Railroad, Chicago, Ill. 60605

Past Presidents

C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania Railroad, Philadelphia, Pa. 19104
L. A. Loggins, Chief Engineer, Southern Pacific Company, Texas and Louisiana Lines, Houston, Tex. 77001

Directors

W. L. Young, Resident Vice President, Norfolk & Western Railway, Norfolk, Va.
T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va. 23213
C. E. Defendorf, Chief Engineer, New York Central System, New York, N. Y. 10017
John Ayer, Jr., Vice President—Operations, Denver & Rio Grande Western Railroad, Denver, Colo. 80217
A. L. Sams, Chief Engineer, Illinois Central Railroad, Chicago, Ill. 60605
D. C. Hastings, Assistant Vice President—Operations, Atlantic Coast Line Railroad, Jacksonville, Fla. 32202
B. B. Lewis, Professor of Railway Engineering, Purdue University, Lafayette, Ind.
H. M. Williamson, Chief Engineer System, Southern Pacific Company, San Francisco, Calif. 94105
H. E. Wilson, Assistant Chief Engineer—System, Atchison, Topeka & Santa Fe Railway, Chicago, Ill. 60604
J. S. Parsons, Engineering Consultant, Erie Lackawanna Railroad, Cleveland, Ohio. 44115
S. H. Poore, Office Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718
F. N. Beighley, Roadway Engineer, St. Louis–San Francisco Railway, Springfield, Mo. 65801

Treasurer

A. B. Hillman, Retired Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago.

Executive Secretary

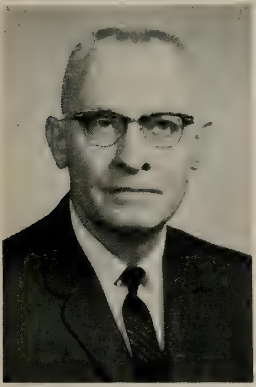
Earl W. Hodgkins, 59 East Van Buren Street, Chicago, Ill. 60605

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Street, Chicago, Ill. 60605

Published by the American Railway Engineering Association, Monthly, January, February, March, November and December; Bi-Monthly, June-July, and September-October, at 2211 Fordem Avenue, Madison, Wis.; Editorial and Executive Offices,
59 Van Buren Street, Chicago 5, Ill.
Second class postage paid at Madison, Wis.
Accepted for mailing at special rate of postage for in Section 1103, Act of October 3, 1917, authorized on June 29, 1918.
Subscription $10 per annum.

Report of Committee 15—Iron and Steel Structures



G. W. Salmon, *Chairman*
D. L. Nord,
Vice Chairman
J. M. Hayes, *Secretary*
E. S. Birkenwald
J. E. South
E. T. Franzen
M. L. Koehler
R. C. Baker
R. W. Gustafson
J. C. King
H. A. Balke
L. S. Beedle
R. S. Bennett
J. E. Bernhardt
E. D. Billmeyer
R. T. Blewitt
H. F. Bober
E. T. Bond
J. C. Bridgefarmer
R. N. Brodie
J. G. Clark
A. G. Cudworth
J. W. Davidson
R. P. Davis (E)
H. E. Dearing
W. E. Dowling
E. F. Garland
G. K. Gillan
G. W. Haffey
C. D. Hanover, Jr.
A. R. Harris
Alfred Hedefine
G. E. Henry
W. C. Howe
W. H. Jameson
E. A. Johnson
W. G. Jones
T. E. Jordan
E. W. Kieckers
K. H. Lenzen
Shu-t'ien Li
J. F. Marsh
E. A. Matney
M. L. McCauley
D. V. Messman
James Michalos
W. G. Mitchell
R. F. Moline
W. H. Munse
G. P. Nagtegaal
C. Neufeld
J. C. Nichols
R. D. Nordstrom
T. G. O'Neil
E. E. Paul
Jimmy Payne
G. H. Perkins
R. A. Peteritas
A. L. Piepmeier
C. A. Roberts
W. E. Robey
D. D. Rosen
Henry Seitz
R. I. Simkins
N. E. Smith
R. D. Spellman
J. E. Stallmeyer
W. M. Thatcher
H. T. Welty (E)
R. H. Wengenroth
Wm. Wilbur
H. N. Wilcox
A. R. Wilson (E)
A. J. Wood
M. O. Woxland
L. T. Wyly

Committee

(E) Member Emeritus.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 15.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Part 1—Revisions of specifications submitted for adoption .... page 292

   Part 2—Revisions of specifications submitted as information to be considered for adoption one year hence .... page 293

2. Design, construction and maintenance of railway roadway signal supports of the bridge and cantilever types, collaborating with the Communication and Signal Section, AAR.

   Investigations and studies are in progress, but there is no information for presentation at this time.

3. Corrosion of deck plates.

   Brief progress report, submitted as information .... page 295

4. Stress distribution in bridge frames:
   (a) Truss bridge research project.
   Brief progress report, submitted as information .... page 296

5. Synthetic resins and other adhesive materials for protective coating and reinforcement, collaborating with Committee 7.
   Your committee is continuing its studies in collaboration with Committee 7, but has no new information to report at this time.

6. Preparation and painting of steel surfaces, collaborating with the Steel Structures Painting Council.
   Brief progress report, submitted as information .... page 296

7. Bibliography and technical explanation of various requirements in AREA specifications relating to iron and steel structures.
   Brief progress report, submitted as information .... page 297

8. Specifications for design of structural plate pipe with diameters greater than 15 ft.
   Brief progress report, submitted as information .... page 297

10. Effect of continuous welded rail on bridges, collaborating with Committee 31—Continuous Welded Rail.
   Your committee continues to gather data on the use of CWR on bridges and, as more experience is gained, expects to add to the information published in Bulletin 583, page 389.

THE COMMITTEE ON IRON AND STEEL STRUCTURES,
G. W. SALMON, *Chairman.*

AREA Bulletin 590, January 1965.

Report on Assignment 1

Revision of Manual

E. S. Birkenwald (chairman, subcommittee), R. T. Blewitt, R. P. Davis, E. T. Franzen, W. H. Jameson, J. F. Marsh, D. V. Messman, C. Neufeld, D. L. Nord, E. E. Paul, D. D. Rosen, R. D. Spellman, J. E. Stallmeyer.

Part 1—Revisions Submitted for Adoption

Your committee submits the following revisions of specifications for adoption and publication in the Manual:

Pages 15–1–1 to 15–1–58, incl.

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

Page 15–1–10, Art. 29:

Revise in accordance with the recommendations published in AREA Proceedings, Vol. 65, page 383, except that: Change "f_b = actual bending unit stress = actual bending stress divided by section modulus of member", to read, "$f_b =$ actual bending unit stress $=$ actual bending moment divided by section modulus of member."

Page 15–1–11, Art. 31:

Revise lines 10 through 18 as follows:

Axial compression, gross section:

For stiffeners of plate girders 20,000

For compression members centrally loaded and with values of l/r not greater than 130:

Riveted ends . . . . $17{,}000 - 0.31\frac{l^2}{r^2}$

Pin ends . . . . $17{,}000 - 0.43\frac{l^2}{r^2}$

$l =$ length of member, in inches.
$r =$ least radius of gyration of member, in inches.

For compression members with values of l/r greater than 130 and for compression members of known eccentricity, see Appendix A.

Page 15–1–39, Art. 1:

Revise the two lines under the definitions of l and r to read: "For compression members with values of l/r greater than 125 and for compression members of known eccentricity, see Appendix A."

Page 15–1–41, Appendix A:

In the last line, change "Sec. B, Art. 8" to read "Sec. C, Art. 1."

Page 15–1–42, Appendix A:

In formulas (1), (2), (3) and (4), change the period after the word "ends" to a comma.

In formula (3), lower the formula number (3) to line up with the line separating the numerator from the denominator.

In formula (4), raise the phrase "For pin ends, $p =$" to line up with the line separating the numerator from the denominator.

In the definition of e_1, change "axi" to "axis."

Pages 15–2–1 to 15–2–73, incl.

SPECIFICATIONS FOR MOVABLE RAILWAY BRIDGES

Page 15–2–27, Art. 12:

In the second line change "$L = 80\sqrt{d^2}$" to read "$L = 80\sqrt[3]{d^2}$."

Part 2—Revisions Submitted as Information

Your committee presents as information the following revisions to be considered for adoption and publication one year hence:

SPECIFICATIONS FOR STEEL RAILWAY BRIDGES

Pages 15–1–7 and 15–1–8, Art. 20:

Revise (a) to read:

(a) To the axle loads specified in Sec. A, Art. 18, there shall be impact forces applied at top of rail, equalling the following percentages of the axle loads:

1. For rolling equipment without hammer blow (diesels, electric locomotives, tenders alone and rolling stock):

For open-deck girder spans .... $\frac{10,000}{100+L}-10$

For ballasted-deck girder spans .... $\frac{10,000}{100+L}-20$

For open-deck truss spans .... $\frac{10,000}{100+L}$

For ballasted-deck truss spans .... $\frac{10,000}{100+L}-10$

In which the percentage shall not exceed 60.

2. For rolling equipment with hammer blow (steam reciprocating locomotives):

For open-deck girder spans .... $\frac{10,000}{100+L}$

For ballasted-deck girder spans .... $\frac{10,000}{100+L}-10$

For open-deck truss spans .... $\frac{10,000}{100+L}+10$

For ballasted-deck truss spans .... $\frac{10,000}{100+L}$

In which the percentage shall not exceed 80.

The formulas for girders shall apply to beam spans, stringers, floorbeams, posts of deck truss spans carrying load from floorbeam only, and floorbeam hangers, in which:

$L =$ length, in feet, center to center of supports for stringers, tranverse floorbeams without stringers, longitudinal girders and trusses (main members).

$L =$ length, in feet, of the longer adjacent supported stringer, longitudinal beam, girder or truss for impact in floorbeams, floorbeam hangers, subdiagonals of trusses, transverse girders, supports for longitudinal and transverse girders and viaduct columns.

RULES FOR RATING EXISTING IRON AND STEEL BRIDGES

Page 15–7–5, Art. 8:

Revise (a) and (b) to read as follows, and add (c) and (d):

(a) The impact shall be determined by the rules for impact in the current AREA Specifications for Steel Railway Bridges, Part 1, this chapter. This impact is made up of two components, consisting of a rolling effect and a direct vertical effect.

(b) The rolling effect is equal to $\frac{100}{S}$, where $S =$ distance center to center of beams, girders or trusses, used singly or in sets.

(c) The direct vertical effect is equal to the impact minus the rolling effect.

(d) Reduction of impact from direct vertical effect will be allowed under the following conditions:

1. For all lengths and types of spans, except truss spans, carrying locomotives with hammer blow, and for all lengths and types of spans carrying rolling

equipment without hammer blow, the vertical effect for speeds less than 40 mph shall reduce in a straight-line variation from full impact at 40 mph to 0.2 of the full effect at 10 mph.

2. For all lengths of truss spans carrying locomotives with hammer blow, the vertical effect for speeds less than synchronous speed shall reduce in a straight-line variation from full effect at synchronous speed to 0.2 of the full effect at 10 mph. Synchronism occurs when the locomotive speed in revolutions per second of drivers equals the natural frequency of the span, in vibrations per second, which is approximately

$$\sqrt{\frac{12}{d+D}}$$

in which d and D are the central deflections in inches, respectively, for dead load and for static live load placed in the position for maximum moment.

Report on Assignment 3

Corrosion of Deck Plates

J. E. South (chairman, subcommittee), R. S. Bennett, E. T. Bond, E. T. Franzen, G. K. Gillan, G. W. Haffey, W. C. Howe, E. A. Johnson, M. L. McCauley, D. L. Nord, J. Payne, A. L. Piepmeier, C. A. Roberts, W. E. Robey, R. D. Spellman.

Your committee submits the following report as information:

AAR Report No. ER-40, Corrosion of Deck Plates After 5 Years of Exposure, was released in January 1964. It was also published as an advance report of Committee 15 in Bulletin 587, pages 73 through 87. In this investigation test plates of several different metals were exposed to a briny environment both at the AAR Research Center and on the Huey Long Bridge, New Orleans, La. The tests conducted at the AAR Research Center are completed. Test plates are still in place on the Huey Long Bridge, however, and additional reports on their performance will be presented in the future. After 5 years of exposure, all the plates showed extensive corrosion except those of 316 stainless steel and 6061–T6 aluminum.

The committee is now considering making a study of the corrosion of the top flanges of deck girders and the resistance to abrasion of various substances that might be cemented to the top flanges of girders.

Your committee has changed the title of this assignment to "Protection of Steel Surfaces" in order to broaden its scope.

Report on Assignment 4

Stress Distribution in Bridge Frames

E. T. Franzen (chairman, subcommittee), L. S. Beedle, E. S. Birkenwald, R. P. Davis, G. K. Gillan, J. M. Hayes, W. H. Jameson, K. H. Lenzen, Shu-t'ien Li, J. Michalos, W. H. Munse, G. P. Nagtegaal, R. D. Nordstrom, J. Payne, R. H. Wengenroth, L. T. Wyly.

a. Truss Bridge Research Project

Your committee submits the following report as information:

As reported a year ago, work on the Truss Bridge Research Project has come to a halt because of lack of funds and the resignation of Dr. John Ely, its director. No test work was done on the project in the last year, but two reports have been issued on earlier test work. One, entitled "Apparatus for Maintaining Constant Loads on an Inelastically Failing Structure," appeared in the September 1963 issue of *Materials Research & Standards,* published by ASTM. The other, entitled "Optical Tooling Techniques for Measuring Translations of Joints and Members of a Space Structure" was published in the June 1964 issue of the Journal of the Structural Division, ASCE Proceedings. One other paper remains to be published, "The Effect of Damaged End Posts on the Ultimate Strength of a Truss Bridge."

Your committee is of the opinion that there is no possibility of any further tests being made on this project.

Report on Assignment 6

Preparation and Painting of Steel Surfaces

Collaborating with the Steel Structures Painting Council

R. C. Baker (chairman, subcommittee), E. D. Billmeyer, A. G. Cudworth, E. F. Garland, G. W. Haffey, E. W. Kieckers, E. A. Matney, R. F. Moline, G. H. Perkins, R. A. Peteritas, D. D. Rosen, H. Seitz, R. I. Simkins, N. E. Smith, A. J. Wood.

Your committee submits the following report as information.

No report can be made at this time on the paint tests mentioned in our last report, because the director of research of the Steel Structures Painting Council could not find the time to make an inspection of the tests. However, F. P. Drew, AAR Research Center, with the aid of the individual railroads involved, is planning to inspect these tests during the coming year. It is expected that the tests will be carried to completion.

For the future, your committee has combined this assignment with Assignment 3 under the title of "Protection of Steel Surfaces."

Report on Assignment 7

Bibliography and Technical Explanations of Various Requirements in AREA Specifications Relating to Iron and Steel Structures

J. G. Clark (chairman, subcommittee), R. N. Brodie, R. P. Davis, C. D. Hanover, Jr., J. M. Hayes, A. Hedefine, W. H. Jameson, D. V. Messman, G. P. Nagtegaal, C. Neufeld, E. E. Paul, H. Seitz, J. E. South, R. H. Wengenroth, W. Wilbur.

Your committee submits the following report as information.

Your committee is now working on a complete revision of Chapter 15 of the Manual. This work is being closely coordinated with the work being progressed under Assignment 7 in order that resulting changes may be adequately covered when the revisions are ready for publication.

Report on Assignment 8

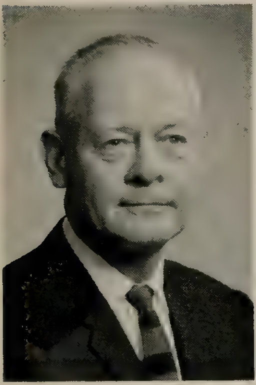
Specifications for Design of Structural Plate Pipe with Diameters Greater than 15 Ft

R. W. Gustafson (chairman, subcommittee), R. S. Bennett, E. D. Billmeyer, H. F. Bober, A. G. Cudworth, J. W. Davidson, W. E. Dowling, G. W. Haffey, W. C. Howe, E. A. Johnson, E. W. Kieckers, G. H. Perkins, R. A. Peteritas, A. L. Piepmeier, H. N. Wilcox, M. O. Woxland.

Your committee submits the following report as information.

The scope of this assignment has been enlarged to cover the revisions necessary in the "Specifications for Corrugated Structural Plate Pipe, Pipe Arches and Arches," Chapter 1 of the Manual. A final draft is under preparation, and it is expected that it will be ready for publication in the January 1966 Bulletin.

Report of Committee 7—Wood Bridges and Trestles



B. E. Daniels, ***Chairman***
D. V. Sartore,
Vice Chairman
J. W. Chambers,
Secretary

R. E. Anderson
R. E. Kuehner
W. L. Anderson
A. L. Leach
J. A. Gustafson
L. R. Kubacki
C. V. Lund
W. A. Thompson, Jr.
D. L. Walker
F. E. Schneider
E. L. Bangs
T. P. Burgess
A. W. Carlson
B. F. Carr, Jr.
H. M. Church (E)
F. H. Cramer (E)
K. L. De Blois
D. J. Engle
J. T. Evans
George Gabel, Jr.

W. A. Genereux
S. L. Goldberg
S. F. Grear (E)
R. W. Gunther
F. J. Hanrahan
J. F. Holmberg
R. H. Hunsinger
L. C. Jones
W. H. Martin
E. A. Matney
T. K. May
J. W. N. Mays
D. H. McKibben, Sr.
C. H. Newlin
W. H. O'Brien
W. A. Oliver
J. G. Shope
J. W. Storer
W. D. Turner
L. W. Wood
Committee

(E) Member Emeritus.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 7.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   The results obtained in the work of several subcommittees have made necessary a general review of Chapter 7 of the Manual. This work will be started this year.

2. Grading rules and classification of lumber for railway uses; specifications for structural timber, collaborating with other interested organizations.

   The committee is revising the Manual material covering the working stresses for softwood lumber in accordance with current grading rules, and is reviewing the U. S. Commercial Standard CS 253–63 for structural glued laminated timber with the thought of substituting this standard for the specifications now in the Manual.

3. Specifications for design of wood bridges and trestles.

   Progress report, with recommendations submitted for adoption .... page 300

4. Methods of fireproofing wood bridges and trestles, including fire-retardant paints.

   No report. Lack of funds has retarded progress in the research work for this assignment.

5. Design of structural glued laminated wood bridges and trestles.

No report. Some progress is being made in developing plans and tables for glued laminated girders and trestle members.

6. Applications of synthetic resins and adhesives to wood bridges and trestles.

Progress report, submitted as information .... page 301

7. Repeated loading of timber structures.

Progress report, submitted as information .... page 302

8. Protection of pile cut-offs.

Because of the shortage of funds, no further tests have been made on the protection of pile cut-offs. The committee will recommend that the scope of the assignment be enlarged to include studies of means, other than by preservatives, for protecting piles against marine organisms; also, studies of various independent installations of protective coatings. In addition, it is hoped that the committee can make and study some installations of its own.

9. Study of in-place preservative treatment of timber trestles.

Progress report, submitted as information .... page 304

10. Non-destructive testing of wood.

Brief progress report, submitted as information .... page 304

The Committee on Wood Bridges and Trestles,
B. E. Daniels, *Chairman.*

AREA Bulletin 590, January 1965.

Report on Assignment 3

Specifications for Design of Wood Bridges and Trestles

W. L. Anderson (chairman, subcommittee), R. E. Anderson, E. L. Bangs, T. P. Burgess, B. F. Carr, Jr., J. W. Chambers, K. L. De Blois, J. T. Evans, George Gabel, Jr., R. W. Gunther, J. A. Gustafson, F. J. Hanrahan, L. C. Jones, L. R. Kubacki, C. V. Lund, E. A. Matney, J. W. Mays, C. H. Newlin, J. G. Shope, W. D. Turner, L. W. Wood.

Under Assignment 7, tests were conducted on full-size bridge stringers under repeated loading by the Engineering Research Division, Association of American Railroads. Data from these tests are published in AAR Reports ER–26 and ER–52.

Study of the data indicates that the horizontal shear strength of timber beams under repeated loading is critical when the beams are loaded to produce maximum deflection. For the usual axle spacing of railway equipment and span lengths for timber railway bridges, maximum deflection occurs when the first wheel is approximately at three times the height of the beam from the support. Paragraph (b) of Art. 5, Sec. D, of Specifications for Design of Wood Bridges and Trestles for Railway Loading, Part 2, Chapter 7 of the Manual, is inconsistent with the above findings. To correct this situation, your committee submits the following recommendations for adoption:

Pages 7–2–1 to 7–2–17, incl.

SPECIFICATIONS FOR DESIGN OF WOOD BRIDGES AND TRESTLES FOR RAILWAY LOADING

On page 7–2–12 delete Art. 5 in its entirety, substituting therefor the following rewritten version:

5. Horizontal Shear

The following procedure shall be used for horizontal shear at the neutral plane:

$$S = \frac{3V}{2bh}$$

in which S = Unit shear in pounds per square inch.
V = Effective shear in pounds.
b = Breadth of beam in inches.
h = Height of beam in inches.

The results obtained must not exceed the allowable unit shear stress.

In calculating the effective shear for use in the formula:

(1) Take into account any relief to the beam under consideration resulting from the loading being distributed to adjacent parallel beams by flooring or other members of the construction.
(2) Neglect all loads within the height of the beam from both supports.
(3) Place the heaviest wheel load at three times the height of the beam from the support.
(4) Treat all other loads in the usual manner.

Report on Assignment 6

Applications of Synthetic Resins and Adhesives to Wood Bridges and Trestles

L. R. Kubacki (chairman, subcommittee), R. E. Anderson, T. P. Burgess, J. W. Chambers, G. Gabel, R. H. Hunsinger, L. C. Jones, T. K. May, D. V. Sartore, F. E. Schneider, J. W. Storer, D. L. Walker.

Your committee submits as information the following brief report on tests of epoxy resin coatings:

On January 10, 1962, 40 steel test plates were installed on the Huey Long Bridge, New Orleans, La. Of these plates, 36 were coated with epoxy-resin systems and 4 were left uncoated. All plates are of A 7 steel, and 7 by ½ by 10 in. in size. They were fastened with ½-in lag screws to the inside spacer timber of the eastbound main on the west approach of the bridge.

The results of this test were published in AAR Research Center Report ER–43, Part 1, entitled, "Field Investigation of Epoxy Resin Coatings on Steel, Two Year Exposure," also in AREA Bulletin 587, September–October 1964.

At the AAR Research Center, epoxy resin coatings 632–1255 and 632–1555, as well as other systems, underwent the standard acceptance tests for waterproofing coatings for exposed concrete surfaces as outlined in Manual Chapter 29. The concrete test specimens, 1 by 3 by 8 in. in size, were proportioned, mixed and cured as specified in the above-mentioned acceptance tests.

The results of these tests were published in AAR Research Center Report ER–43, Part 2, entitled, "Laboratory Investigation of Epoxy Resin Waterproofing Coatings on Concrete," and in AREA Bulletin 587, September–October 1964.

Report on Assignment 7

Repeated Loading of Timber Structures

C. V. Lund (chairman, subcommittee), R. E. Anderson, W. L. Anderson, A. W. Carlson, B. F. Carr, Jr., D. J. Engle, W. A. Genereux, F. J. Hanrahan, J. F. Holmberg, L. C. Jones, L. R. Kubacki, W. H. Martin, T. K. May, W. A. Oliver, F. E. Schneider, J. G. Shope, W. D. Turner, L. W. Wood.

Your committee presents as information the following synopsis of Report ER–52, Laboratory Investigation to Determine Static and Repeated-Load Strength of Full-Size Southern Pine Glued Laminated Stringers, recently released by the Engineering Research Division, Association of American Railroads. This is the second report on tests conducted on full-size bridge stringers in repeated loading. The first report, pertaining to similar tests on glued laminated Douglas fir stringers, appeared in Bulletin 576, January 1963.

The investigation is part of a program of tests of full-size stringers in static and repeated loading to obtain data needed in re-evaluating allowable working stresses, undertaken in cooperation with the lumber industry and the Forest Products Laboratory of the United States Department of Agriculture.

Laboratory Investigation to Determine Static and Repeated-Load Strength of Full-Size Southern Pine Glued Laminated Stringers*

In this series a total of 24 untreated glued laminated southern pine stringers, fabricated to meet the specifications of the Southern Pine Inspection Bureau for combination 1–9 grade, were tested. The stringers were 7 by 16¼ in. in cross section, 14 ft long. Three of the stringers were tested statically, and the remainder in repeated loading, applying two equal loads spaced 4 ft 8 in apart (with one exception) on a span length of 12 ft 10 in. The tests were planned with particular emphasis on the determination of horizontal shear strength, and the effect of load position on shear resistance. Thus the first load was placed at either 1½, 2¼ or 3 times the depth of the stringer from an end support; also a few additional load positions were investigated. Tests were carried to failure or to approximately 2,000,000 cycles of the applied loads, whichever occurred first. Five stringers which did not fail under repeated loading were subsequently tested statically to note the effect of the repeated-load test on residual strength.

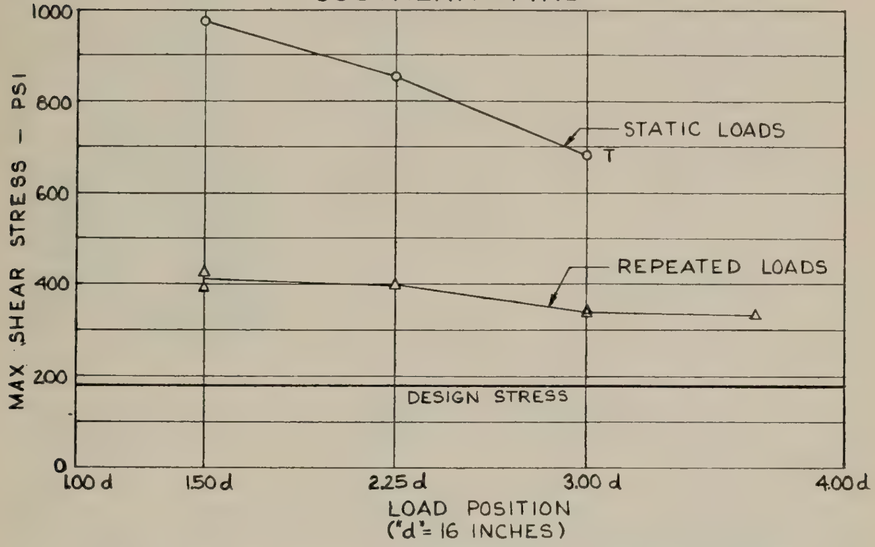
The complete results of this series may be found in Report ER–52. The report also includes data on physical properties as determined by the Forest Products Laboratory.

In static tests 2 stringers failed in bearing and 1 in tension. In repeated-load tests 11 stringers failed in horizontal shear, 3 in tension and 1 in bearing; 6 stringers did not fail.

---

* Copies of the complete report are available from the AAR Research Center, 3140 S. Federal St., Chicago, Ill. 60616, in the form of Report ER–52.

FIG. I
LABORATORY INVESTIGATION OF GLUED LAMINATED STRINGERS
EFFECT OF LOAD POSITION ON SHEAR STRENGTH
SOUTHERN PINE



NOTE : VALUES SHOWN FOR REPEATED LOADS ARE THOSE WHICH WERE SUSTAINED FOR 2,000,000 CYCLES.
•T - TENSION FAILURE

As in the case of the tests on fir stringers, the results show that as the loads approach the support and the end shear increases, the unit shear resistance also increases. Conversely, the unit shear resistance reduces as the loads are moved toward the center of the span (see Fig. 1).

The horizontal shear strength of the beams in this series, at 2,000,000 cycles, is estimated to approximate 400 psi with the first load located at 1½ times the depth of the beam from the support (1½ *d*), 375 psi with the first load at 2¼ *d*, and 340 psi with the first load at 3*d*. Supplementary tests with loads placed substantially symmetrical about the center line of the span showed continuing lower shear resistance. The currently allowable working stress for glued-laminated Southern pine of this grade is 180 psi, based however on long-time duration of static loading. The modulus of rigidity at static design loads, computed from strain rosette readings, likewise varied considerably, depending on load position.

A study of strain-gage readings failed to reveal any consistent relationship between measured strains and the manner of failure, nor was imminent failure detected by either a change in measured strain or visual observation.

Five stringers which did not fail in the repeated-load test were later subjected to static tests at the several load positions. It is significant that all developed a residual strength substantially equal to that of the stringers which had been subjected to static test only.

Tests of physical properties conducted at the Forest Products Laboratory yielded an average specific gravity of the beams of 0.52. There was a rather wide range from high to low, and it was found that in the fabrication of the beams a large proportion ended up with laminations of high specific gravity at one end. Moisture content averaged 9.8 percent, with only moderate variation from high to low.

Report on Assignment 9

Study of In-Place Preservative Treatment of Timber Trestles

D. L. Walker (chairman, subcommittee), E. L. Bangs, T. P. Burgess, D. J. Engle, K. L. De Blois, A. L. Leach, C. H. Newlin, F. E. Schneider, W. A. Thompson, J. W. Storer.

Your committee submits as information the following report of progress in the study of the assigned subject.

In-place preservative treatment of timber trestles got its start on the railroads in July 1953 when six ballasted-deck trestles averaging 34 years in age were treated on the Gulf, Mobile & Ohio Railroad. The work was done by a service company which, dealing in allied problems in utility poles, had been asked if a method of in-place treatment might not be worked out to prolong the life of bridges. Subsequent investigations by this company led to the development of the method used to treat the six bridges mentioned above.

Briefly, this method consists of boring holes in a prescribed pattern in the bridge members to be treated and forcing a fungicidal liquid under pressure into any decay voids found. This is designed to stop the decay by creating a residual toxicity fatal to decay fungi, thus prolonging the members' life.

The service company doing this work has inspected these treated bridges at various intervals, making tests to determine the residual toxicity of the wood. It reports that in the oldest treated members, the first ¼ in of wood surrounding the decay pockets still retains enough treatment to be above the threshold of decay. In some cases, the first ½ in is still above that threshold.

Your committee will continue its study of this industry-developed procedure and present its findings in future reports. If money becomes available, your committee will also supplement these reports with reports on information developed in its own work.

Report on Assignment 10

Non-Destructive Testing of Wood

F. E. Schneider (chairman, subcommittee), W. L. Anderson, E. L. Bangs, George Gabel, Jr., W. A. Genereux, R. W. Gunther, F. J. Hanrahan, L. R. Kubacki, R. E. Kuehner, C. V. Lund, W. B. MacKenzie, W. H. Martin, E. A. Matney, C. H. Newlin, D. V. Sartore, J. W. Storer, W. A. Thompson, Jr.

The following report is submitted as information:

A detailed progress report on this subject was made last year, but your committee has been unable to progress the assignment further because of the lack of funds. However, because of the interest of bridge inspectors and engineers in nuclear devices or other means of determining the internal condition of piles and bridge timbers without damaging the timber, the AAR Research Department and your committee are keeping in contact with all companies and researchers claiming to have such equipment.

Report of Committee 8—Masonry

J. R. Williams,
Chairman

R. J. Brueske,
Vice Chairman

W. R. Wilson
F. A. Kempe, Jr.
J. M. Williams
E. D. Ripple
W. P. Hendrix
E. R. Blewitt
W. E. Brakensiek
J. W. Briscoe
H. C. Brown
M. W. Bruns
N. D. Bryant
A. W. Carlson
Maurice Coburn (E)*
G. W. Cooke
L. F. Currier
E. J. Daily
M. T. Davisson
J. W. DeValle
J. W. Dolson
B. M. Dornblatt
D. H. Dowe
W. J. Eney
J. A. Erskine
T. L. Fuller
N. O. Geuder, Sr.
R. W. Gilmore (E)
G. P. Hayes
S. B. Holt
H. W. Hopkins
A. K. Howe
H. R. Hutchens
J. R. Iwinski
A. C. Johnson
T. R. Kealey
R. J. Klueh
R. E. Kuban
A. N. Laird (E)
G. F. Leyh
E. F. Manley
P. R. Matthews
L. M. Morris (E)
M. S. Norris
David Novick
R. E. Pearson
J. E. Peterson
Milton Pikarsky
D. E. Richardson
W. H. Robertson
D. B. Roth
F. A. Russ, Jr.
J. H. Sawyer, Jr.
H. H. Schmidt
Everett Scroggie
J. E. Scroggs
W. R. Shafer
G. R. Shay
C. H. Splitstone (E)
S. A. Stutes
Anton Tedesko
W. C. Teng
M. F. Tigrak
G. A. Vanderpool
Neil Van Eenam
J. W. Weber
S. G. Wintoniak
G. A. Wolf
R. J. Wright
Committee

(E) Member Emeritus.
* Died My 8, 1964.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 8.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, including recommended revisions .... page 306
2. Design of masonry structures, collaborating with Committees 1, 5, 6, 7, 15, 28 and 30.
   Progress report, including rules for rating existing concrete structures submitted as information .... page 307
3. Foundations and earth pressures, collaborating with Committees 1, 6, 7, 15 and 30.
   Brief progress statement, submitted as information .... page 311
4. Deterioration and repair of masonry structures.
   Progress report, including guide for use of epoxy compounds in the repair and restoration of concrete submitted as information .... page 311

6. Prestressed concrete for railway structures, collaborating with Committee 6. Progress report, including recommended additions to Manual material covering specifications for design and construction of prestressed concrete trestles, and revisions to Manual material covering specifications for prestressed concrete; also detail plans for prestressed through voided box beams, submitted as information, and AAR laboratory reports on box beams and epoxy resin bonded beams, also submitted as information .... page 315

7. Quality of concrete and mortars, collaborating with Committee 6. Progress report, including revision of ASTM specification references submitted for adoption .... page 322

8. Waterproofing for railway structures, collaborating with Committees 6, 7 and 15.
Progress report, submitted as information .... page 323

THE COMMITTEE ON MASONRY,
J. R. WILLIAMS, *Chairman.*

AREA Bulletin 590, January 1965.

MEMOIR

Maurice Coburn

Maurice Coburn, Member Emeritus of Committee 8—Masonry, died on May 8, 1964, at the age of 88. He is survived by a son, two granddaughters and a sister.

Mr. Coburn was born in Cleveland, Ohio, and was graduated from the Case Institute of Technology in 1897. For many years he was employed by the Pennsylvania Railroad in the maintenance of way department in Indianapolis, Chicago and Cincinnati.

Mr. Coburn joined the American Railway Engineering Association in 1905, serving as a director in 1922 and 1923. He became a Life Member in 1939. Prior to joining Committee 8—Masonry, he had been a member of Committee 16—Economics of Railroad Location, Committee 21—Economics of Railway Operation, and had served as member and chairman of Committee 6—Buildings. His service on Committee 8—Masonry started in 1933. He was appointed Member Emeritus in 1954.

In Mr. Coburn's passing we lose a member who was closely associated with the founders of the AREA and who, over the years, had worked diligently for Committee 8.

J. R. WILLIAMS,
Chairman.

Report on Assignment 1

Revision of Manual

W. R. Wilson (chairman, subcommittee), R. J. Brueske, G. W. Cooke, W. P. Hendrix, F. A. Kempe, E. D. Ripple, J. M. Williams.

Your committee recommends the adoption of the revisions to the Manual set forth in Assignments 6 and 7.

Report on Assignment 2

Design of Masonry Structures

Collaborating with Committees 1, 5, 6, 7, 15, 28 and 30

F. A. Kempe (chairman, subcommittee), J. W. Briscoe, H. C. Brown, A. W. Carlson, E. J. Daily, N. O. Geuder, Sr., A. N. Laird, F. A. Russ, Jr., E. Scroggie, A. Tedesko, J. W. Weber, G. A. Wolf.

Your committee is assembling information to permit rewriting Part 12—Concrete Poles, and revising Part 2—Plain and Reinforced Concrete Members, and Part 10—Specifications for Reinforced Concrete Culvert Pipe.

There is presented below, as information, a tentative draft of Rules for Rating Existing Concrete Bridges, with the thought that the rules will be presented next year for adoption and publication in the Manual. Comments and criticisms regarding the proposed rules are invited.

RULES FOR RATING EXISTING CONCRETE BRIDGES

1. Classification

Concrete railway bridges shall be classified according to their rated carrying capacity as determined by the rules specified herein. The work of classifying bridges shall be as described in Classification of Railway Bridges, Part 7, Chapter 15, of the AREA Manual.

2. General

Except as otherwise provided in these rules, the Specifications for Design of Plain and Reinforced Concrete Members, Specifications for Reinforced Concrete Arches, Specifications for Reinforced Concrete Rigid-Frame Bridges of one Span, Specifications for Design and Construction of Reinforced Concrete Trestles for Railway Loading, or Specifications for Design and Construction of Reinforced Concrete Box Culverts, this Chapter, as the case may be, shall govern.

3. Carrying Capacity

The carrying capacity of a bridge shall be determined by the computation of stresses based on authentic records of the design, details, materials, workmanship, and physical condition, including data obtained by inspection (and tests if the records are not complete and it is deemed necessary). If deemed advisable, field determination of stresses shall be made and the results given due consideration in the final assignment of the carrying capacity. For a specific service the location and behavior under load shall be taken into account.

4. Inspection

An inspection of the bridge shall be made to determine:

(a) Whether the actual sections and details conform to the drawings.
(b) Any additions to the dead load not shown on the plan, such as heavier rail, deeper ballast section, walks, pipelines, conduits, signal devices, and wire supports.
(c) The position of the track with respect to the center line of the bridge.
(d) Any loss of concrete. All loose concrete surfaces should be removed before making this determination.

(e) Any loss of steel due to corrosion, where steel has been exposed due to loss of concrete. This determination should be made by caliper measurements after removal of scale.

(f) The physical condition, noting such conditions as excessive cracking, at points of maximum moment and at points of maximum shear, caused by passing trains; noting also frozen expansion bearings.

(g) Uneven settlement of supports of continuous spans.

5. Computation of Stresses

The computation of stresses shall be made for the details, as well as for the main members, giving particular attention to:

(a) The increased load carried by any beam, girder, slab or column due to the eccentricity of the load. This applies to bridges on tangent where the tracks are off center, as well as to bridges on curves.

(b) Spacing of web reinforcement, bond and anchorage of main steel, and splices in longitudinal reinforcement.

(c) Column moments due to continuous construction or eccentricity of loading.

6. Loads and Forces

Stresses shall be computed for the following loads and forces:

Dead load
Live load
Impact
Centrifugal force
Other lateral forces
Longitudinal forces

7. Dead Load

The dead load shall be the weight of the bridge, including the track, ballast, and fill, together with that of any other fixed loads.

8. Live Load

The live load shall be one of the Cooper E series, other standard loading, or a load consisting of a specific locomotive or other equipment, depending on the purpose for which the rating is desired.

If the live load is to be a specific locomotive and cars (or other equipment), complete data shall be obtained, including the spacing of axles and the static load on each axle.

The lateral and longitudinal distribution of the axle loads to the structure shall be determined as specified in Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter.

9. Impact

(a) The impact shall be determined by the rules for impact in the Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter.

(b) Reduction of impact will be allowed as follows: for speeds less than 40 mph the impact shall be reduced in a straight-line variation from full effect at 40 mph to 0.5 of the full effect at 10 mph.

10. Centrifugal Force

Centrifugal force shall be determined as specified in Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter.

11. Other Lateral Forces

The wind force shall be assumed as 20 lb per sq ft on the vertical projection of the structure, applied at the center of gravity of the vertical projection, plus a moving load of 200 lb per lin ft on the train, applied 8 ft above the top of rail. The wind force shall be assumed to act horizontally in a direction perpendicular to the center line of the track. This loading is predicated on the reasoning that when the wind velocity exceeds 70 mph a train will operate at reduced speed, if it operates at all.

If considered justifiable by the engineer, the wind forces on a bridge and the train may be reduced to not less than one-half of those required above.

If deemed advisable by the engineer, a lateral force shall be added to provide for the effect of the nosing of the locomotive, which shall be a single moving force equal to $\frac{1}{16}$ of the weight of one locomotive without tender applied at the top of the rail in either lateral direction at the center of either the leading or trailing truck. The resulting vertical effect shall be neglected.

12. Longitudinal Forces

The longitudinal force shall be determined as specified in the Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter.

13. Live Load and Impact on Multiple-Track Bridges

The application of the live load and the impact to multiple-track bridges shall be as specified in the Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter.

14. Permissible Stresses

(a) *Ultimate Compressive Strength* f'_c

The ultimate compressive strength of the concrete shall be taken as the 28-day ultimate strength of the concrete, if records of same are available. If there is no record of the ultimate compressive strength of the concrete, it shall be assumed as 3000 psi for concrete which has not become badly weathered. If the concrete has become badly weathered the ultimate compressive strength should be assumed as not more than 2500 psi, and a lower value should be used if deemed necessary by the engineer.

In the event that the concrete stress proves to be critical, the ultimate compressive strength of the concrete may be determined by Standard Methods of Securing, Preparing, and Testing Specimens from Hardened Concrete for Compressive and Flexural Strengths, ASTM designation C 42. All core holes shall be filled with concrete having a 28-day ultimate compressive strength equal to or higher than that of the structure.

Epoxy bonding compound, to be approved by the engineer, shall be used to bond the new concrete to the existing concrete.

(b) *Modular Ratio* n

The modular ratio n shall be determined as specified in the Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter, using for f'_c the ultimate compressive strength of the concrete as determined above.

(c) *Concrete*

The permissible unit stress for the concrete shall be taken as $1.2k$, where k is the allowable unit stress for concrete given in the Specifications for Design of Plain and Reinforced Concrete Members, Part 2, this Chapter.

(d) *Reinforcement*

Tension in flexural members f_s (with or without axial loads):

Structural-grade steel bars	$0.8y$
Intermediate-grade steel bars	$0.7y$
Hard-grade steel bars	$0.6y$
Wrought iron	$0.8y$
Wire mesh or cold-drawn steel wire not exceeding ½ in. in diameter when used in one-way solid slabs only	$0.7y$
but not to exceed	34,000 psi

Tension in web reinforcement f_w:

All grades of steel	24,000 psi
Wrought iron	20,000 psi

Compression in column verticals f'_s:

Structural-grade steel bars	$0.6y$
Intermediate-grade steel bars	$0.6y$
Hard-grade steel bars	$0.5y$
Wrought iron	$0.6y$

Compressive reinforcement in flexural members:

All grades of steel	24,000 psi
Wrought iron	20,000 psi

Compression in composite column f_r:

All grades of steel	24,000 psi
Wrought iron	20,000 psi

Compression in combination columns f'_r:

Open-hearth or bessemer steel	$\frac{0.8y}{18{,}000}\left(15{,}000 - \frac{1}{4}\frac{l^2}{r^2}\right)$
Wrought iron	$\frac{0.8y}{15{,}000}\left(12{,}500 - 0.21\frac{l^2}{r^2}\right)$

Compression in pipe columns f''_r:

Open-hearth or bessemer steel	$\left[18{,}000 - 70\frac{l}{r}\right]\frac{0.8y^2}{810{,}000{,}000}$

Where l is the unsupported length of the column
r is the radius of gyration of the steel section
y is the yield point of the material

15. Action to Be Taken

If the stresses exceed those permissible under these rules, the speed or the loading shall be restricted so that the permissible stresses will not be exceeded; otherwise, the bridge shall be placed on falsework until it is strengthened or renewed. When the permissible stresses are closely approached, or when the physical condition of the main members or the details is not good, the bridge shall be kept under frequent inspection as long as it is continued in service.

Report on Assignment 3

Foundations and Earth Pressures

Collaborating with Committees 1, 6, 7, 15 and 30

G. W. Cooke (chairman, subcommittee), M. T. Davisson, J. W. DeValle, B. M. Dornblatt, J. A. Erskine, T. R. Kealey, E. F. Manley, D. Novick, M. Pikarsky, W. H. Robertson, G. R. Shay, S. A. Stutes, W. C. Teng, N. Van Eenam.

Under this assignment your committee is developing (a) specifications for imbedment of poles, (b) specifications for sheet-pipe retaining walls, and (c) a bibliography on the effect of earthquake forces on pier foundations, and reports that progress has been made.

Report on Assignment 4

Deterioration and Repair of Masonry Structures

J. M. Williams (chairman, subcommittee), E. R. Blewitt, W. E. Brakensiek, D. H. Dowe, H. W. Hopkins, A. K. Howe, R. J. Klueh, P. R. Matthews, J. E. Peterson, D. E. Richardson, J. H. Sawyer, J. E. Scroggs.

Your committee is considering revision of Part 14—Repairing and Solidifying Masonry Structures, Chapter 8, of the Manual, to include the use of epoxy resins.

Your committee also has prepared and submits as information the following guide for the use of epoxy compounds in the repair and restoration of concrete.

GUIDE FOR THE USE OF EPOXY COMPOUNDS IN THE REPAIR AND RESTORATION OF CONCRETE

GENERAL

The epoxy resin compounds to be considered in the repair and restoration of concrete consist of two liquid components. The basic ingredient of one component is the resin while the basic ingredient of the other component is a curing agent. Each component is individually stable. However, when they are mixed in a fixed ratio, a chemical reaction takes place which changes the mixture from a liquid to a tough plastic solid in a relatively short time, depending on temperature, volume and surface area. Heat has a tendency to hasten this reaction; the mixture cures faster on a hot day than on a cold day. After it has cured, the solidified material will not melt, flow, flush or bleed and when used properly has low shrinkage. The strength of the bond, if the epoxy is applied to properly prepared surfaces, will usually exceed the strength of the material being joined.

The epoxy resin as supplied by the manufacturer combined with the pure curing agent has only a limited use. In most cases the base resin and curing agent are modified by adding flexibilizers, extenders, diluents and fillers to create products designed to meet particular requirements. A specific epoxy compound should be used only for the purpose for which it is intended. The formulator's or manufacturer's instructions should be followed in all cases.

SURFACE PREPARATION

Before attempting to apply epoxy resin compounds, consideration must be given to the proper preparation of the surfaces to which the compounds are to be applied. Two surface conditions must be obtained if the application is to be successful.

(a) The surface must be strong and sound.
(b) The surface must be dry and clean, free from oil, grease and other surface contaminants.

To obtain proper adhesion, all loose and unsound material must be removed. This may require the use of certain mechanical, pneumatic or hand demolition tools. Dust and debris may then be removed by blowing with oil-free compressed air, by hosing with water, by brushing or brooming, or with a vacuum cleaner.

Sound surfaces which do not require removal of loose concrete must, nevertheless, be precleaned to remove oil, dirt and other substances detrimental to the bond of epoxy compounds. While several cleaning methods are available, sandblasting is considered the best. If sandblasting is not practicable, other mechanical means may be used, bearing in mind that a roughened surface is essential.

Where sandblasting or other mechanical means is not feasible, cleaning of the concrete may be accomplished by acid etching. Horizontal surfaces that are contaminated should first be cleaned of oil and grease with strong detergents and finally treated with a 15- to 20-percent muriatic acid solution. After application of the acid, the surface must be thoroughly flushed with clean water and surface dried.

PREPARATION OF EPOXY COMPOUND FOR USE

It is essential to follow the formulator's or manufacturer's recommendations for best application procedures, working temperatures and allowable pot life. All materials must be within the recommended temperature range before mixing, and if the work is being done indoors, proper ventilation must be provided.

Thorough mixing of all components is necessary. However, in the interest of economy, care should be taken to see that no more material is mixed at one time than can be used within the pot life specified by the formulator or manufacturer.

If the resin portion and the converter portion are furnished in contrasting colors, the mixing time can be determined by the time required to attain a uniform color. If color contrast is not apparent, a 1-gal batch should be mixed with a spatula for about 10 min or with a low-speed power paint mixer for about 5 min. The mixing container should be of larger capacity than the volume mixed. For example, a 3-gal container might be used for a 1-gal batch. If sand or aggregate is to be added, it should be stirred in after the liquid components are thoroughly mixed.

When the liquid components are furnished as a unit in two containers, the entire contents of both containers should be mixed at one time.

GENERAL APPLICATION METHODS

Epoxy compounds can be applied by brush, roller, spray gun, trowel, screed or squeegee, whichever may be the most convenient and efficient for the job. In some instances, where the viscosity of the compound is low, the material may be poured in place.

The practical air temperature range for the application of an epoxy compound is 60 to 90 F. At lower temperatures curing is excessively prolonged. At higher temperatures the working time is so short that proper application is quite difficult.

When necessary to place an epoxy mixture against a form which is to be removed, it is necessary that the form be protected with silicone paper or polyethylene.

Since most epoxy compounds bond well only to dry surfaces, it is necessary on a job exposed to the weather to halt the application if it rains. Work should be resumed only when the surface is again dry.

A supply of solvent such as toluol, xylol, methyl ethyl ketone or similar materials should be kept on hand for cleaning equipment and all tools before the epoxy has hardened. The solvents should never be added to the epoxy compound mix, as this could ruin the mix.

SPECIFIC APPLICATIONS

Epoxy compounds designed for certain purposes should be used only for those purposes. On that basis, the following applications have proved advantageous in concrete repair and restoration.

1. Protective Overlays

The epoxy compound should be applied uniformly over the prepared surface with brush, roller, broom, screed or spray gun. A skid-resistant surface may be created by scattering silica sand, emery grit, roofing granules or similar material over the wet coating immediately after application. The amount of aggregate to be used will vary from 1.5 lb per sq yd for thin coatings to 15 lb per sq yd for heavy coatings.

2. Patching

The epoxy compound is usually mixed with well graded fine aggregate free of deleterious material. The aggregate should be dry. The amount of fine aggregate used will vary from 3 to 6 parts to 1 part of epoxy compound by volume. Increasing the amount of fine aggregate will extend the curing time and increase voids.

3. Crack and Joint Sealing

Joints in concrete that are not expected to undergo further movement may be sealed in much the same manner as cracks. Large openings may be sealed either with an epoxy compound, an epoxy compound mortar, or portland cement mortar bonded by an epoxy compound. In the latter case, the epoxy compound is sprayed or brushed into the opening to coat both exposed surfaces. While the epoxy compound is still tacky, a 1 to 2½ portland cement mortar is forced into the crack. For vertical surfaces this must be a dry-pack mortar. When the mortar is about to set, the surface should be tooled to force the mortar more tightly into the joint.

Epoxy compound mortar may be forced into the crack in much the same manner. It may be desirable to prime the crack with an epoxy compound before placing the mortar.

Cracks as narrow as 0.006 in can be sealed with epoxy compounds. Cracks in horizontal surfaces, if wide enough, can sometimes be sealed by pouring the epoxy compound into them; however, to seal cracks in vertical surfaces and the narrowest cracks in horizontal surfaces, it is necessary to apply the epoxy compound by pressure.

4. Bonding New Concrete to Old

Epoxy compounds used for bonding new concrete to old must be chosen from those formulations which develop adequate bond in the presence of water. The epoxy compound should be uniformly applied to the prepared surface of the old concrete, using no solvents. As soon as feasible and while the epoxy compound is still tacky, the portland cement concrete should be placed. The concrete thus placed should have a low slump to reduce shrinkage.

5. Bonding Hardened Concrete to Hardened Concrete

Precast elements may be bonded to other such elements or to hardened cast-in-place concrete by preparing both surfaces for the epoxy compound, applying the compound to both surfaces and pressing them together. Between vertical surfaces, provision must be made to prevent the epoxy compound from escaping.

6. Grouting

Properly prepared anchor bolts and dowels may be grouted in place by inserting them in cleaned holes in the concrete and filling the holes with an epoxy compound.

7. Epoxy Bearing Pads for Leveling Bridge Shoes

It is often necessary to level bridge shoes supported on concrete or masonry piers. Quite frequently, the work has to be done under traffic and between the passage of trains. Certain epoxy compounds are particularly adaptable to this use because they develop high compressive strengths in a comparatively short time.

In this operation it is necessary to erect a form of correct size and at proper elevation. The form should be protected with silicone paper or polyethylene to facilitate its removal. The form must be well sealed at the bottom to prevent any leakage of the epoxy compound.

In the case of stone masonry the epoxy compound may be poured without the addition of fine aggregate. This eliminates the necessity of finishing, as the material is liquid and seeks a level surface. For concrete surfaces, however, because of the extreme heat generated, it has been found necessary to add fine aggregate to the mixture to dissipate part of the heat. Otherwise, the concrete surfaces will crack. Three parts of fine aggregate to one part of epoxy compound by volume has been found to give a mixture that will protect the concrete and can be readily finished. Although the necessary compressive strengths will not be obtained as quickly when the fine aggregate is added, it has been found that at temperatures in excess of 70 F, the proper epoxy compound used with 3 parts of fine aggregate, can withstand traffic within 3-hr after placement.

8. Epoxy Mortar Toppings

The epoxy compound or polysulfide-epoxy binder is used with sand or gravel or both to resurface deteriorated or spalled concrete floor surfaces and bridge decks.

The aggregate should be dry, clean and properly graded so as to provide an impervious, chemically resistant wearing surface. Generally the amount of aggregate by volume will vary from 3 to 6 parts to 1 part of epoxy or binder.

Toppings from ⅛ to ½ in thick have proved most economical and durable. Permanent screed bars laid out in checker-board fashion aid in placing and leveling the mortar mix. In the screeding operation the use of a 6-in-diameter galvanized pipe of sufficient length to span the screeds is generally better than troweling to obtain a compacted, level surface.

9. Flexible Joint Sealer

Two-part sealants based on polysulfide liquid polymer are available to meet the need for high performance in sealing joints in dams, tunnels, bridge decks, curtain-wall panels and buildings. This type of sealant provides exceptional adhesion to concrete and mortar surfaces and also ample flexibility for the expansion and contraction of joints without adhesive or cohesive failure.

The thoroughly mixed sealants are applied to properly prepared joint slots by pouring directly from the container, or by use of a caulking gun or a trowel, and allowed to cure in accordance with the manufacturer's instructions. A bond breaker such as silicone paper or aluminum foil placed in the bottom of the joint slot is necessary so that the sealant will bond only to the two sides of the slot.

CURING

As soon as the epoxy resin and curing agent are mixed together, a chemical reaction begins. As it continues, heat is generated which is greater in the mixing pot than when spread in a thin layer. To avoid premature curing in the mixer, mixing and spreading operations must be coordinated. If the mixture is confined in a container, the heat cannot escape, which accelerates the reaction. The use of a shallow container as a mixing pot will reduce this heat.

HANDLING PRECAUTIONS

Safe handling of epoxy materials can be accomplished by:

a. Working in a well ventilated area.
b. Using disposable equipment wherever possible.
c. Careful attention to personal cleanliness and protection.

Safety goggles and rubber gloves are recommended when handling either epoxy compounds or acids. Frequent washing with soap and water is also recommended.

No amount of equipment, however, will substitute for worker education. When working with epoxy compounds, it is necessary to keep personnel and equipment clean. The proper handling of epoxy compounds is not a dangerous occupation, but the possibility of a burn, damaged eye or other loss-of-time accidents makes safe handling practices absolutely essential. Anyone who is susceptible to epoxy compounds should not be allowed to work where these compounds are being used.

Report on Assignment 6

Prestressed Concrete for Railway Structures

Collaborating with Committee 6

E. D. Ripple (chairman, subcommittee), W. J. Eney, T. L. Fuller, R. W. Gilmore, H. R. Hutchens, G. F. Leyh, J. E. Scroggs, M. F. Tigrak, G. A. Vanderpool, W. R. Wilson, R. J. Wright.

Your committee presents its report on Assignment 6 in five parts, as follows:

Part 1—Recommended revisions to certain material now in the Manual.

Part 2—Recommended addition to the Manual of Specifications for Design and Construction of Prestressed Concrete Trestles for Railway Loading, Using Box Beams.

Part 3—Tentative Manual material, consisting of three detail drawings showing through-voided single- and double-box beams.

Part 4—Report on AAR laboratory investigation of prestressed concrete box beams.

Part 5—Report on AAR laboratory investigation of epoxy shear keys.

Part 1—Manual Revisions

Your committee submits for adoption the following recommendations with respect to Chapter 8 of the Manual:

Pages 8–17–1 to 8–17–24, incl.

SPECIFICATIONS FOR DESIGN, MATERIALS AND CONSTRUCTION OF PRESTRESSED CONCRETE STRUCTURES

Reapprove with the following revisions:

Page 8–17–5, Sec. H, Art. 2—Prestressing Steel: In the second line of the paragraph under the heading *a. Temporary Stresses,* change "0.68" to "0.70."

Page 8–17–6, Sec. H, Art. 4—Concrete: Add the following under the heading *a. Temporary Stresses:*

"Where cracking of top sections will be objectionable owing to lack of waterproofing or for other reasons, the values given for tension shall be zero."

Page 8–17–12, Sec. k, Art. 4—Minimum Quantity of Web Reinforcement: Add the following paragraph:

"In no case shall the area of web reinforcement furnished at the ends be less than that necessary to resist a vertical force equal to 4 percent of the initial prestress. This reinforcement shall be placed within a distance equal to one-fourth of the depth of the member from the end, the end stirrup to be as close to the end as possible."

Part 2—Recommended Additions to Manual

Your committee recommends for adoption and publication in the Manual, "Specifications for Design and Construction of Prestressed Concrete Trestles for Railway Loading, Using Box Beams, as published in Bulletin 583, January 1964, pages 364 through 374, with the following changes therein:

Page 368, Art. 7—Keyways: Change the third sentence of the second paragraph to read, "Approximately three parts of sand to one part of resin by volume will generally give a pourable mix."

Page 368 add the following new Art. 8:

8. Waterproofing

When required, the ballast trough shall be waterproofed by applying a three-ply membrane and a protective cover to the surfaces as specified in Part 2, Chapter 29. This membrane shall be Type C, consisting of two layers of bitumen-treated felt, one middle layer of bitumen-treated cotton fabric and four moppings of bitumen. The protective cover shall be asphalt plank.

Part 3—Tentative Manual Material

Your committee presents as information three tentative drawings, Figs. 7, 8 and 9, (see pages 318, 319, and 320) showing details of through-voided single- and double-box prestressed beams, and requests comments and criticism thereon with the thought of presenting them next year for adoption and publication in the Manual.

Part 4—AAR Laboratory Investigation of Prestressed Concrete Box Beams

The report of this committee which appeared in Bulletin 583, January 1964, contains a resumé of the laboratory investigation completed during 1963. The following report summarizes the work done in 1964.

The investigational work to determine the static and repeated-load strength of box beams cast with regular mineral aggregate was performed with nine full-size beams. The first four beams cast were marked R1, R2, R3 and R4. As indicated in last year's report, the design of the beams was changed to eliminate undesirable tensile cracking in the tops of the beams. Accordingly, beams R1A and R2A were cast with a revised strand pattern. At the same time, three beams, R3A, R4A and R5A, were cast without end blocks or a center diaphragm and are known as through-voided beams. The results of the test on beams R1 to R4, incl., and R5A were indicated in the report for 1963.

Beams R1A and R2A were subjected to repeated loading. R1A sustained a load range of 60,000 lb minimum to 100,000 lb maximum at each load point and failed after 539,700 cycles. Failure was due to strand breakage. R2A had a load range of 19,000 lb minimum to 83,000 lb maximum and did not fall under 2,014,200 cycles. This indicates that the fatigue strength for 2,000,000 cycles of the revised-design beams is at least 1.7 times design load which was the same as the indicated fatigue strength of the originally designed beams. Furthermore, since no tensile cracks were observed in the tops of these beams, the revised strand pattern is apparently effective.

Beams R3A and R4A were also subjected to repeated loads. The range of loading was the same as used for R1A and R2A to obtain comparative data. R3A did not fail under 2,038,400 cycles of loading. R4A failed after 521,600 cycles by strand breakage. This indicates that these through-voided beams have fatigue strength comparable to the conventional type.

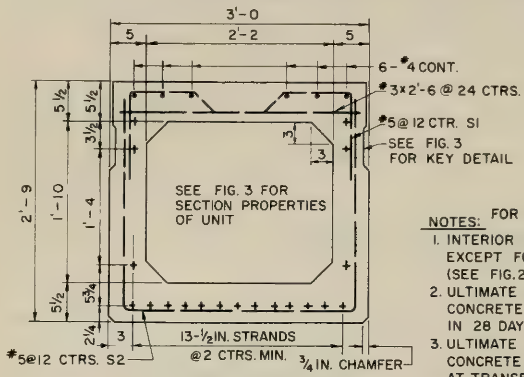
A full report on the investigation of these nine beams will be published in a subsequent issue of the bulletin.

As a continuation of the study of prestressed concrete box beams during 1964, five through-voided beams were cast, using lightweight aggregate. One of these beams, L1, has been placed outside the AAR laboratory on supports 27 ft 0 in apart. It has been loaded with concrete blocks to simulate the dead load of track and ballast. Strain and deflection readings are being taken periodically to determine the effect of this sustained load. Another beam, L2, was subjected to a static load to failure, with the following results:

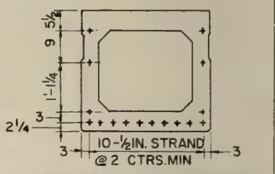
		Deflection
Design load	48 kips per load point	0.13 in
Cracking load	72 kips per load point	0.20 in
Ultimate load	151 kips per load point	1.75 in (estimated)

(Text continued on page 321)

FIG. 7
AMERICAN RAILWAY ENGINEERING ASSOCIATION
PRESTRESSED CONCRETE RAILWAY TRESTLE
3'-0 WIDE THROUGH-VOIDED PRESTRESSED UNITS



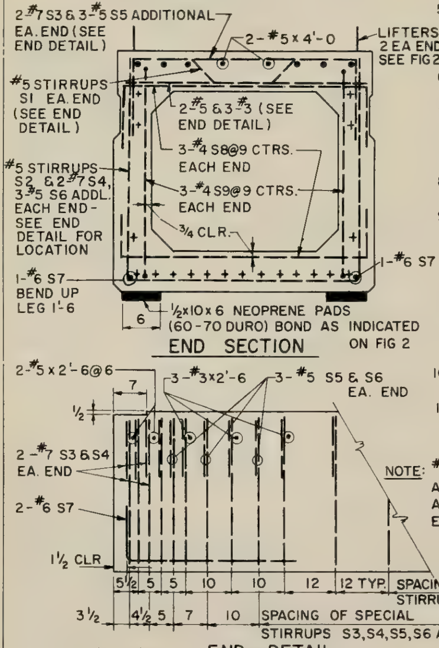
TYPICAL SECTION
(19 - ½ IN STRAND, f'_s = 250,000 PSI)



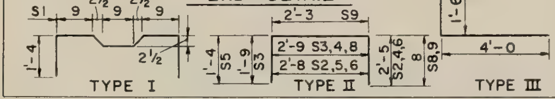
ALTERNATE STRAND PATTERN
FOR 16-½IN. HIGH STRENGTH STRAND f'_s=270,000 PSI

NOTES:

1. INTERIOR UNITS SHOWN; EXTERIOR UNITS SAME EXCEPT FOR KEY, CURB STEEL AND DRIP NOTCH (SEE FIG. 2).
2. ULTIMATE COMPRESSIVE CYLINDER STRENGTH OF CONCRETE SHALL BE NOT LESS THAN 5,000 PSI IN 28 DAYS.
3. ULTIMATE COMPRESSIVE CYLINDER STRENGTH OF CONCRETE SHALL BE NOT LESS THAN 4,000 PSI AT TRANSFER OF PRESTRESSING FORCE.
4. CONCRETE SHALL BE AIR-ENTRAINED CONCRETE AS SPECIFIED IN CHAPTER 8, PART 1, SEC. J, PAR. 4.
5. ALL PRESTRESSING STRANDS SHALL BE ½ IN., 7 WIRE UNCOATED, STRESS-RELIEVED, WITH MIN. f'_s = 250,000 PSI MEETING THE REQUIREMENTS OF ASTM DESIGNATION A416
6. INITIAL PRESTRESS SHALL BE 0.70 f'_s=25,200 LB. PER. STRAND
7. NON-PRESTRESSED REINFORCEMENT SHALL BE NEW BILLET INTERMEDIATE GRADE STEEL, MEETING THE REQUIREMENTS OF ASTM DESIGNATIONS A15 AND A 305.
8. ALL REINFORCEMENT SHALL HAVE A MIN. COVER OF 1½ IN. OF CONCRETE, UNLESS OTHERWISE NOTED.
9. AT DISCRETION OF ENGINEER, HIGH STRENGTH ½ IN. STRAND MAY BE SUBSTITUTED FOR STRAND SPECIFIED IN 5 & 6 ABOVE. THIS STRAND SHALL BE 7 WIRE UNCOATED STRESS RELIEVED AND SHALL CONFORM TO ASTM DESIGNATION A416 EXCEPT THAT MIN. f'_s SHALL BE 270,000 PSI, NOM. MIN. A_s = .115 IN.^{2}, NOM. WT. PER. 1000 FT. = 525 LB. INITIAL PRESTRESS SHALL BE .70 f'_s = 28,910 LB. PER. STRAND. (SEE ALTERNATE STRAND PATTERN)
10. SEE FIGS. 1, 2, 3 & 8 FOR FURTHER DETAILS OF PRESTRESSED UNITS
11. AT ENGINEERS DISCRETION, END DIAPHRAGMS AS DETAILED ON FIG 8 MAY BE USED ON END SPAN OF TRESTLE, TO SEAL END OF HOLLOW VOID.


2-#7 S3 & 3-#5 S5 ADDITIONAL EA. END (SEE END DETAIL)
2-#5 x 4'-0
LIFTERS 2 EA END SEE FIG 2.
#5 STIRRUPS S1 EA. END (SEE END DETAIL)
2-#5 & 3-#3 (SEE END DETAIL)
3-#4 S8@9 CTRS. EACH END
#5 STIRRUPS S2 & 2-#7 S4, 3-#5 S6 ADDL. EACH END - SEE END DETAIL FOR LOCATION
3-#4 S9@9 CTRS. EACH END
¾ CLR.
1-#6 S7
1-#6 S7 BEND UP LEG 1'-6
6
½x10x6 NEOPRENE PADS (60-70 DURO) BOND AS INDICATED ON FIG 2
END SECTION
2-#5 x 2'-6@6
7
½
3-#3x2'-6
3-#5 S5 & S6 EA. END
2-#7 S3 & S4 EA. END
2-#6 S7
1½ CLR
NOTE: #4 BARS, S8 & S9 ARE ALSO REQ'D AT EA. END (SEE END SECTION)
5½ 5 5 10 10 12 12 TYP.
SPACING OF TYPICAL STIRRUPS, S1 & S2 AT EA. END
3½ 4½ 5 7 10
SPACING OF SPECIAL STIRRUPS S3,S4,S5,S6 AT EA. END

END DETAIL



NO.PCS	SIZE	MARK	LENGTH	TYPE
16	3		2'-6	STR.
6	4		27'-6	STR.
4	5		4'-0	STR.
4	5		2'-6	STR.
31	5	S1	5'-6	I
31	5	S2	7'-6	II
4	7	S3	6'-3	II
4	7	S4	7'-7	II
6	5	S5	5'-4	II
6	5	S6	7'-6	II
4	6	S7	5'-6	III
12	4	S8	4'-1	II
12	4	S9	3'-7	II

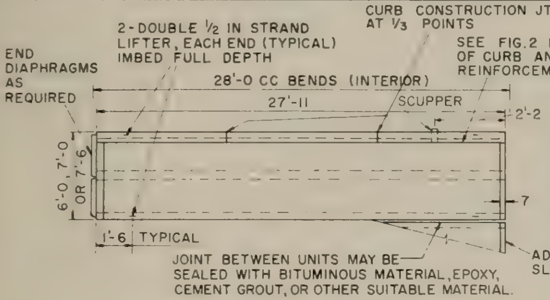
ALL BAR DIMENSIONS ARE OUT TO OUT

FIG. 8

AMERICAN RAILWAY ENGINEERING ASSOCIATION

PRESTRESSED CONCRETE RAILWAY TRESTLE

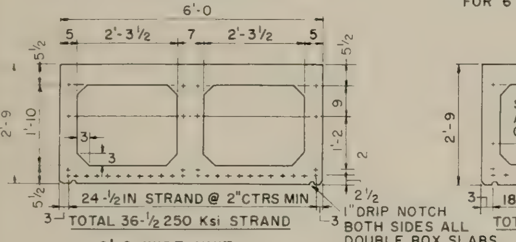
THROUGH-VOIDED, DOUBLE BOX PRESTRESSED UNITS - DIMENSIONS, STRAND REQUIREMENTS


CURB CONSTRUCTION JT AT 1/3 POINTS
2-DOUBLE 1/2 IN STRAND LIFTER, EACH END (TYPICAL) IMBED FULL DEPTH
SEE FIG. 2 FOR DETAILS OF CURB AND CURB REINFORCEMENT
END DIAPHRAGMS AS REQUIRED
28'-0 CC BENDS (INTERIOR)
27'-11
SCUPPER
2'-2
6'-0, 7'-0 OR 7'-6
7
1'-6 TYPICAL
JOINT BETWEEN UNITS MAY BE SEALED WITH BITUMINOUS MATERIAL, EPOXY, CEMENT GROUT, OR OTHER SUITABLE MATERIAL.
ADJACENT SLAB

TYPICAL DOUBLE BOX SLAB PLAN

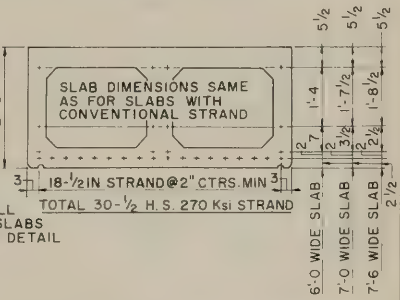
SECTION PROPERTIES	6'-0 WIDE	7'-0 WIDE	7'-6 WIDE
AREA-in^2	1,202	1,334	1,400
I-in^4	170,718	195,726	208,370
Yt-in	16.50	16.50	16.50
Yb-in.	16.50	16.50	16.50
Zt-in^3	10,340	11,862	12,628
Zb-in^3	10,340	11,862	12,628

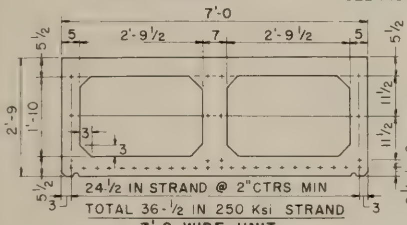
CONVENTIONAL STRAND $f_s' = 250{,}000$ PSI
(SEE FIG 9 FOR MILD STEEL REINF.)


6'-0
5
2'-3 1/2
7
2'-3 1/2
5
5 1/2
2'-9
1'-10
9
1'-2
2
3
3
5 1/2
2 1/2
24-1/2 IN STRAND @ 2" CTRS MIN
3
TOTAL 36-1/2 250 Ksi STRAND
3
1" DRIP NOTCH BOTH SIDES ALL DOUBLE BOX SLABS SEE FIG 2 FOR DETAIL

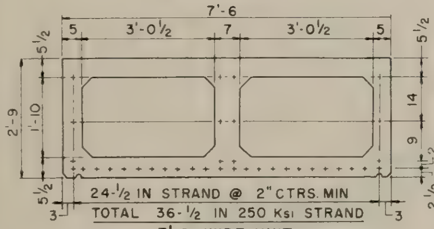
6'-0 WIDE UNIT

STRAND PATTERN FOR ALTERNATE HIGH STRENGTH STRAND ($f_s' = 270{,}000$ PSI) FOR 6'-0, 7'-0 & 7'-6 SLABS

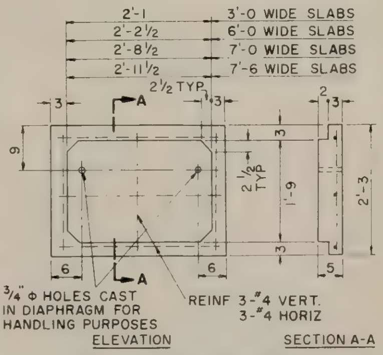

SLAB DIMENSIONS SAME AS FOR SLABS WITH CONVENTIONAL STRAND
2'-9
5 1/2
5 1/2
5 1/2
1'-4
1'-7 1/2
1'-8 1/2
7
3 1/2
2 1/2
2
2
2
2 1/2
3
18-1/2 IN STRAND @ 2" CTRS. MIN
3
TOTAL 30-1/2 H. S. 270 Ksi STRAND
6'-0 WIDE SLAB
7'-0 WIDE SLAB
7'-6 WIDE SLAB



7'-0 WIDE UNIT


7'-6
5
3'-0 1/2
7
3'-0 1/2
5
5 1/2
5 1/2
2'-9
1'-10
14
9
2
5 1/2
2 1/2
24-1/2 IN STRAND @ 2" CTRS. MIN
3
TOTAL 36-1/2 IN 250 Ksi STRAND
3

7'-6 WIDE UNIT



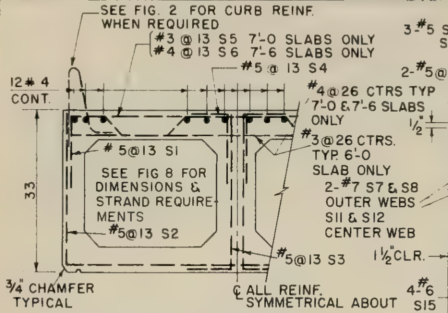
5" PRECAST END DIAPHRAGM

DIAPHRAGM TO BE SET IN CEMENT OR EPOXY RESIN GROUT IN END OF HOLLOW UNIT AS REQ'D (SEE FIG. 7, NOTE 11)

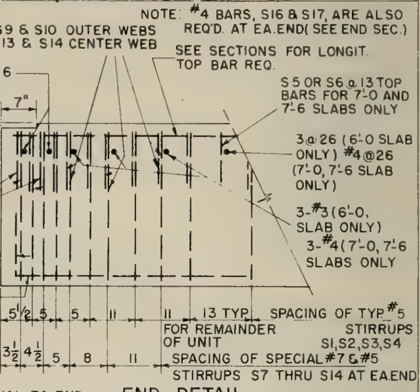
FIG. 9

AMERICAN RAILWAY ENGINEERING ASSOCIATION
PRESTRESSED CONCRETE RAILWAY TRESTLE

THROUGH-VOIDED, DOUBLE BOX PRESTRESSED UNITS
MILD STEEL REINFORCEMENT — 6'-0, 7'-0 & 7'-6 UNITS


SEE FIG. 2 FOR CURB REINF. WHEN REQUIRED
#3 @ 13 S5 7'-0 SLABS ONLY
#4 @ 13 S6 7'-6 SLABS ONLY
#5 @ 13 S4
12 # 4 CONT.
#4@26 CTRS TYP 7'-0 & 7'-6 SLABS ONLY
#3@26 CTRS. TYP. 6'-0 SLAB ONLY
2-#7 S7 & S8 OUTER WEBS S11 & S12 CENTER WEB
# 5@13 S1
SEE FIG 8 FOR DIMENSIONS & STRAND REQUIREMENTS
#5@13 S2
33
#5@13 S3
3/4" CHAMFER TYPICAL
℄ ALL REINF. SYMMETRICAL ABOUT ℄
4-#6 S15

TYPICAL SECTION

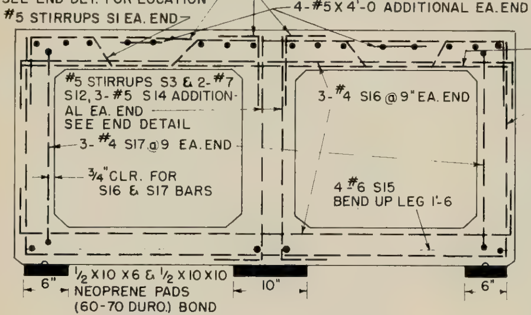

3-#5 S9 & S10 OUTER WEBS S13 & S14 CENTER WEB
NOTE: #4 BARS, S16 & S17, ARE ALSO REQ'D. AT EA. END (SEE END SEC.)
SEE SECTIONS FOR LONGIT. TOP BAR REQ.
2-#5@6
7"
1/2"
S 5 OR S6 @ 13 TOP BARS FOR 7'-0 AND 7'-6 SLABS ONLY
3@26 (6'-0 SLAB ONLY) #4@26 (7'-0, 7'-6 SLAB ONLY)
3-#3 (6'-0, SLAB ONLY)
3-#4 (7'-0, 7'-6 SLABS ONLY
1 1/2" CLR.
5 1/2 5 5 11 11 13 TYP.
SPACING OF TYP. #5 STIRRUPS S1,S2,S3,S4 FOR REMAINDER OF UNIT
3 1/2 4 1/2 5 8 11
SPACING OF SPECIAL #7 & #5 STIRRUPS S7 THRU S14 AT EA. END

END DETAIL

2-#7 S7, 3-#5 S9 ADDITIONAL EA. END SEE END DET. FOR LOCATION

#5 STIRRUPS S1 EA. END

#5 STIRRUPS S4 & 2-#7 S11, 3-#5 S13 ADDITIONAL EA. END SEE END DET.


4-#5 X 4'-0 ADDITIONAL EA. END
#5 STIRRUPS S3 & 2-#7 S12, 3-#5 S14 ADDITIONAL EA. END SEE END DETAIL
3-#4 S17 @ 9 EA. END
3/4" CLR. FOR S16 & S17 BARS
3-#4 S16 @ 9" EA. END
4-#6 S15 BEND UP LEG 1'-6
6"
10"
6"
1/2 X 10 X 6 & 1/2 X 10 X 10 NEOPRENE PADS (60-70 DURO.) BOND AS INDICATED ON FIG. 2

2-#5 & 3-#3 (6'-0 SLABS) OR 3-#4 (7'-0 & 7'-6 SLABS) EA. END - SEE END DETAIL

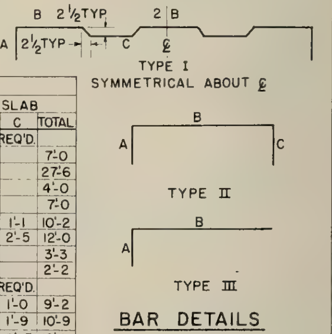
#5 STIRRUPS S2 & 2-#7 S8, 3-#5 S10 ADDITIONAL EA. END - SEE END DETAIL FOR LOCATION

END SECTION

NOTES

1. NOTES 2 THROUGH 11 ON FIG. 7 APPLY FOR UNITS SHOWN ON FIG. 8 & 9
2. ADDITIONAL DETAILS OF BOX UNITS ARE GIVEN ON FIGS. 1 THROUGH FIG. 7

NO. REQ'D	SIZE	MARK	TYPE	LENGTH (SEE BAR DETAILS) 6'-0 SLAB A	B	C	TOTAL	7'-0 SLAB A	B	C	TOTAL	7'-6 SLAB A	B	C	TOTAL
16	3		STR.				5'-6		NOT REQ'D.				NOT REQ'D.		
16	4		STR.		NOT REQ'D.						6'-6				7'-0
12	4		STR.				27'-6				27'-6				27'-6
8	5		STR.				4'-0				4'-0				4'-0
4	5		STR.				5'-6				6'-6				7'-0
29	5	S1	I	1'-4	0'-9½	0'-10	8'-8	1'-4	0'-11½	1'-0	9'-8	1'-4	1'-0½	1'-1	10'-2
29	5	S2	II	2'-5	5'-8	2'-5	10'-6	2'-5	6'-8	2'-5	11'-6	2'-5	7'-2	2'-5	12'-0
29	5	S3	III	0'-10	2'-5		3'-3	0'-10	2'-5		3'-3	0'-10	2'-5		3'-3
29	5	S4	III	0'-10	1'-4		2'-2	0'-10	1'-4		2'-2	0'-10	1'-4		2'-2
20	3	S5	II		NOT REQ'D.			1'-0	6'-8	1'-0	8'-8		NOT REQ'D.		
20	5	S6	II		NOT REQ'D.				NOT REQ'D.			1'-0	7'-2	1'-0	9'-2
4	7	S7	II	1'-9	5'-9	1'-9	9'-3	1'-9	6'-9	1'-9	10'-3	1'-9	7'-3	1'-9	10'-9
4	7	S8	II	2'-5	5'-9	2'-5	10'-7	2'-5	6'-9	2'-5	11'-7	2'-5	7'-3	2'-5	12'-1
6	5	S9	II	1'-4	5'-8	1'-4	8'-4	1'-4	6'-8	1'-4	9'-4	1'-4	7'-2	1'-4	9'-10
6	5	S10	II	2'-5	5'-8	2'-5	10'-6	2'-5	6'-8	2'-5	11'-6	2'-5	7'-2	2'-5	12'-0
4	7	S11	III	1'-3	1'-9		3'-0	1'-3	1'-9		3'-0	1'-3	1'-9		3'-0
4	7	S12	III	1'-3	2'-5		3'-8	1'-3	2'-5		3'-8	1'-3	2'-5		3'-8
6	5	S13	III	0'-10	1'-4		2'-2	0'-10	1'-4		2'-2	0'-10	1'-4		2'-2
6	5	S14	III	0'-10	2'-5		3'-3	0'-10	2'-5		3'-3	0'-10	2'-5		3'-3
8	6	S15	III	1'-6	4'-0		5'-6	1'-6	4'-0		5'-6	1'-6	4'-0		5'-6
12	4	S16	II	0'-8	5'-9	0'-8	7'-1	0'-8	6'-9	0'-8	8'-1	0'-8	7'-3	0'-8	8'-7
12	4	S17	II	0'-8	2'-3	0'-8	3'-7	0'-8	2'-3	0'-8	3'-7	0'-8	2'-3	0'-8	3'-7



BAR DETAILS

ALL BAR DIMENSIONS ARE OUT TO OUT

The ultimate load was 3.1 times the design load, and failure was by crushing of the concrete. Whereas the revised conventional and through-voided beams had 13 strands in the lower flange and 3 strands in each side wall, these lightweight beams had one additional strand in each side wall. These additional strands were required to compensate for greater expected losses in prestress.

Beams L3, L4 and L5 were cast for repetitive loading. L3 was loaded with a range of 60,000 lb minimum to 100,000 lb maximum and did not fail. A total of 2,043,700 cycles was applied. The remaining two beams, L4 and L5, will be subjected to a greater range of load in order to produce a failure.

The investigation of the beams with regular mineral aggregate was conducted jointly by the Prestressed Concrete Institute and the AAR. The PCI furnished the beams and the AAR performed the laboratory work. The lightweight beam investigation is being conducted cooperatively between the PCI, the Nebraska Prestressed Concrete Company, the Carter–Waters Corporation, the Expanded Shale Clay and Slate Institute and the AAR.

Part 5—ARR Laboratory Investigation of Epoxy Shear Keys

A previous investigation at the AAR Laboratory demonstrated that an epoxy rein-sand mixture is an effective material for bonding together multiple concrete bridge beams for load transfer. A brief report of this investigation was included in the report of this committee for last year. The following report summarizes the investigational work conducted during 1964 on this subject.

A modified block shear test is being used to determine the static and repeated load strength of various bonding materials. Three blocks, each 18 in wide, 24 in high and 12 in long, form the assembly. The two outside blocks bear on elastomeric pads of 60 durometer. Load is applied to the center block to produce shearing stresses along the interfaces. No tie rods are used.

For the total program, it is planned to evaluate an epoxy resin, portland cement, and a non-shrinking fast-setting material. Both straight-sided blocks and blocks with keyways are to be used. The results to date, using straight-sided blocks, are as follows:

Spec. No.	*Material*	*Depth of Bond, Inches*	*Type of Test*	*Total No. of Cycles*	*Ultimate Shear Stress, PSI*
EX-1	Epoxy resin–sand	8	Static	....	63
EX-2	Epoxy resin–sand	8	Repeated load	2,258,000	47
EX-2	Epoxy resin–sand	8	Static		92
EX-3	Epoxy resin–sand	8	Repeated load	2,073,400	53
EX-3	Epoxy resin–sand	8	Static		74
EX-4	Epoxy resin–sand	8	Repeated load	122,700	66
EX-6	Epoxy resin–sand	24	Repeated load	985,900	250
EX-7	Epoxy resin–sand	24	Repeated load	1,685,900	225
CM-1	Portland cement–sand	24	Static	....	11
CM-2	Portland cement–sand	24	Repeated load	97,500	8

In the epoxy-resin-bonded specimens, the concrete failed, not the bond material. The epoxy resin bond pulled off the surface of the block.

The Portland cement bonded specimens failed along the bond line between the mortar and the block.

Report on Assignment 7

Quality of Concrete and Mortars

Collaborating with Committee 6

W. P. Hendrix (chairman, subcommittee), M. W. Bruns, N. D. Bryant, L. F. Currier, J. W. Dolson, S. B. Holt, A. C. Johnson, R. E. Kuban, G. F. Leyh, L. M. Morris, M. S. Norris, W. R. Shafer, J. W. Weber, S. G. Wintoniak.

Your committee is currently revising the pamphlet "How to Make Good Concrete" to include the use of ready-mix concrete, and is making good progress in this work.

Your committee offers for adoption the following editorial revisions with respect to Chapter 8 of the Manual.

Pages 8–19–1 to 8–19–3, incl.

ASTM SPECIFICATIONS AND DESIGNATIONS

Pages 8–19–1 to 8–19–3, incl.

A 6–63T, change to A 6–64, and delete "(Tentative)" from title.
A 15–62T, change to A 15–64, and delete "(Tentative)" from title.
A 16–62T, change to A 16–64, and delete "(Tentative)" from title.
A 160–62T, change to A 160–64, and delete "(Tentative)" from title.
A 408–62T, change to A 408–64, and delete "(Tentative)" from title.
A 431–62T, change to A 431–64, insert "High-Strength" ahead of "Deformed" in in title, and delete "(Tentative)" from title.
A 432–62T, change to A 432–64, and delete "(Tentative)" from title.
C 33–63, change to C 33–64.
C–39–61, change to C 39–64.
C 76–63T, change to C 76–64T.
C–87–63T, change title to "Effect of Organic Impurities in Fine Aggregate on Strength of Mortar (Tentative)."
C 91–63, change to C 91–64.
C 109–63, change to C 109–64.
C–123–63T, change to C 123–64, and delete "(Tentative)" from title.
C 131–55, change to C 131–64T, and change title to "Resistance to Abrasion of Small-Size Coarse Aggregate by Use of the Los Angeles Machine (Tentative)."
C 142–55T, change to C 142–64T.
C 150–63, change to C 150–64.
C 175–63, change to C 175–64.
C 205–63T, change to C 205–64T.
C 227–63T, change to C 227–64, and delete "(Tentative)" from title.
C 235–62T, change to C 235–64, and delete "(Tentative)" from title.
C 289–63T, change to C 289–64, and delete "(Tentative)" from title.
C 330–60T, change to C 330–64T.
C 340–63T, change to C 340–64T.
C 342–61T, change to C 342–64, and delete "(Tentative)" from title.

After Designation C 360–63 add the following new item:

C 535–64T, Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine (Tentative).
D 15–62T, change to D 15–62 aT.
D 676–59T, delete.
D 797–58, change to D 797–64.
D 1149–62T, change to D 1149–64, and delete "(Tentative)" from title.

After Designation D 1149–64 add the following new item:

D 2240–64T, Indentation Hardness of Rubber and Plastics by Means of a Durometer (Tentative).

Report on Assignment 8

Waterproofing for Railway Structures

Collaborating with Committees 6, 7 and 15

R. J. Brueske (chairman, subcommittee), A. K. Howe, J. R. Iwinski, R. E. Pearson, M. Pikarsky, D. B. Roth, H. H. Schmidt.

The work of this subcommittee is divided into three parts, as follows:

a. Rewrite Part 3, Chapter 29, Coatings for Dampproofing. After spending a considerable amount of time studying this matter the committee has decided to prepare a specification that covers the use of asphalt and coal tar pitch as dampproofing coatings. Both of these materials are readily available.

b. Investigation of the Waterproofing Qualities of Epoxy Resins and Related Materials. Work is being carried on at the AAR laboratory as time permits.

c. Investigation of Membrane Waterproofing Joint and Edge Sealers. No work has been done this year. We are recommending dropping this assignment in 1965 and replacing it with a new one, "Investigation of the Waterproofing Qualities of Butyl Membrane Waterproofing," as an increasing number of railroads are using this material. Funds for this investigation were requested by the committee and have been included in the 1965 Engineering Division Research Budget.

Report of Committee 24—Cooperative Relations with Universities

J. F. Davison, *Chairman*

R. H. Beeder,
Vice Chairman

H. E. Hurst

A. V. Johnston
J. F. Pearce
T. M. Adams
J. L. Alvord
B. G. Anderson
H. C. Archdeacon
W. S. Autrey
J. B. Babcock (E)
George Baylor
W. R. Bjorklund
J. H. Brown
J. B. Clark
T. P. Cunningham
R. P. Davis (E)
R. J. Fisher
W. S. Gates, Jr.
C. E. R. Haight
W. W. Hay
C. L. Heimbach
L. J. Hoffman
R. P. Howell
W. H. Huffman
S. R. Hursh (E)*
Claude Johnston

Frank Kerekes
W. S. Kerr
H. E. Kirby (E)
E. C. Lawson
B. B. Lewis
R. W. Middleton
H. R. Moore
Jerry Neben
R. C. Nissen
W. A. Oliver
J. A. Peebles
J. E. Perry
G. B. Pruden
M. M. Ray, Jr.
R. B. Rice
R. W. Ripley
V. J. Roggeveen
J. A. Rust
P. S. Settle, Jr.
E. R. Shultz
W. D. Taylor
Egons Tons
T. D. Wofford, Jr.
Committee.

(E) Member Emeritus.
* Died March 16, 1964.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 24.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Stimulate greater appreciation on the part of railway managements of:
   (a) the importance of bringing into the service selected graduates of colleges and universities and for recruiting such graduates and of retaining them in service.
   (b) the necessity for providing adequate means for recruiting such graduates and retaining them in service.
   Progress report, submitted as information .... page 327

2. Stimulate among college and university students a greater interest in the science of transportation and its importance in the national economic structure by
   (a) cooperating with and contributing to the activities of student organizations in colleges and universities, and
   (b) presenting to students and their counselors a positive approach to the attractive and interesting features of the railroad industry and the advantages of choosing railroading as a career.
   Progress report, submitted as information .... page 328

3. The cooperative system of education, including summer employment in railway service.
   Progress report, submitted as information .... page 330

5. Ways in which railroads can cooperate with universities in developing research, including the revising of "Suggested Topics for Theses on Railroad Subjects."
   Progress report, submitted as information .... page 333

6. Procedures for orienting and developing newly employed engineering personnel.
   This assignment is complementary to Assignment 8 and the two subcommittee chairmen are developing a joint approach to their assignments. The extent and nature of the training required by newly employed engineers appears to be reaching a higher level because of changes in the engineering college curricula, but the subcommittee has not collected sufficient data upon which to base a report. Study is continuing.

7. Stimulate an interest by college and university staff members in current railroad problems and practices, including AREA membership.
   Progress report, submitted as information .... page 333

8. Current changes in engineering education and their implications regarding employment of future graduates by the railroad industry.
   This assignment is complementary to Assignment 6 and the two subcommittee chairmen are developing a joint approach to their assignments. Information to date indicates a disappearance of railway-oriented subjects, and a trend toward greater emphasis on the basic principles of mathematics and science at the expense of more specialized courses. Study is continuing.

THE COMMITTEE ON COOPERATIVE RELATIONS WITH UNIVERSITIES,
J. F. DAVISON, *Chairman.*

AREA Bulletin 590, January 1965.

MEMOIR

Samuel R. Hursh

AREA, and railroad circles generally, lost a popular and valued member in the death of Samuel R. Hursh in Philadelphia on March 16, 1964.

Mr. Hursh—"Sam" to thousands of friends all over the country—had been a member of AREA since 1928 and a Life Member since 1960. He was an active member of Committee 4—Rail, from 1946 to 1961; of the Special Committee on Continuous Welded Rail, from 1952 to 1961; and of Committee 24—Cooperative Relations With Universities, from 1946 to 1959. He was chairman of the latter committee from 1948 to 1950, and a Member Emeritus since 1959. He was especially active in getting young engineers interested in railroad work and in obtaining their services for the industry.

In the course of his 43-year career on the Pennsylvania Railroad, from which he retired on March 31, 1959, as assistant vice president, Mr. Hursh pioneered widely in the development of tools for mechanized track maintenance. Prominent among his patents was one for a mechanized tie tamper that is in wide use. Another of his important activities on the Pennsylvania was preparatory engineering work on the proposed merger of that railroad with the New York Central—a proposal now pending before the Interstate Commerce Commission.

Among the professional honors he received was Pennsylvania State University's Distinguished Alumnus Award for 1960. The citation read:

> "To Samuel R. Hursh, for the several outstanding achievements that have marked his long career with a major industrial enterprise; for the development of valuable labor-saving railroad equipment and machinery; and for his devotion to and service in the cause of the American economic system."

It was a fitting and deserved tribute to an able and popular member of our Association and of our industry.

Report on Assignment 1

Stimulate Greater Appreciation on the Part of Railway Managements of

(a) the Importance of Bringing into the Service Selected Graduates of Colleges and Universities, and

(b) the Necessity for Providing Adequate Means for Recruiting Such Graduates and of Retaining Them in Service

A. V. Johnston (chairman, subcommittee), B. G. Anderson, H. C. Archdeacon, R. H. Beeder, J. H. Brown, J. F. Davison, C. E. R. Haight, S. R. Hursh, E. C. Lawson, R. W. Middleton, Jerry Neben J. A. Peebles, G. B. Pruden, J. A. Rust, W. D. Taylor, T. D. Wofford, Jr.

The work of this subcommittee is being conducted in two separate parts. The previous investigation under this assignment was based on a questionnaire completed by some 2000 university graduates in engineering to determine the characteristics of railway-employed engineers. The information from the questionnaires has been transferred to punch cards and some analysis has been undertaken. The committee decided, however, that the information would be retained for subcommittee use until the data had been completely analyzed, it being considered preferable to issue a complete report rather than a series of separate progress reports. The analysis is continuing.

The current activity of this subcommittee concerns a salary survey to determine how the salaries of railway engineers compare with the salaries of engineers in other industries. While considerable salary data are available, much of it is of a confidential nature which cannot be used in a published report. Efforts are being made to obtain data from other sources for use by the subcommittee.

This progress report on Assignment 1 is presented as information.

Report on Assignment 2

Stimulate Among College and University Students a Greater Interest in the Science of Transportation and Its Importance in the National Economic Structure by

(a) Cooperating with and Contributing to the Activities of Student Organizations in Colleges and Universities, and

(b) Presenting to Students and their Counselors a Positive Approach to the Attractive and Interesting Feature of the Railroad Industry and the Advantages of Choosing Railroading as a Career

B. B. Lewis (chairman, subcommittee), T. M. Adams, W. S. Autrey, J. B. Babcock, R. H. Beeder, W. R. Bjorklund, J. H. Brown, J. B. Clark, J. F. Davison, W. S. Gates, Jr., W. H. Huffman, S. R. Hursh, W. S. Kerr, H. R. Moore, J. E. Perry, M. M. Ray, Jr., R. W. Ripley, P. S. Settle, Jr.

Your committee reports that the following railroad-oriented activities on the part of railway men, professors and others occurred on college campuses during the year.

J. E. Hoving, *assistant chief engineer, Northern Pacific Railway,* reports that he participated in a panel discussion on the many phases of civil engineering before members of the Junior Engineering Technical Societies on the University of Washington campus. Mr. Hoving dealt with the field of transportation, with emphasis on railways. Approximately 150 high-school students were in attendance, who evidenced a great interest in civil engineering.

C. J. Henry, *chief engineer, Pennsylvania Railroad,* reports that G. A. Williams, *area engineer* at Pittsburgh, spoke about railroad maintenance practices and employment opportunities on the railroads. Mr. Williams showed a movie which illustrated the use of modern maintenance equipment. Mr. Henry also said that J. E. South, *system engineer structures,* spoke on the design problems encountered in railroad structural maintenance, and illustrated by color slides the work being done to renovate the Pennsylvania's bridge over the Susquehanna River at Perryville, Md. This talk was given to the Student Chapter of the American Road Builders Association of the University of Pittsburgh.

Vincent J. Roggeveen, *Professor of Transportation Planning,, Stanford University,* reports the occurrence of several railroad-related presentations at the university during the year. The New York Central Railroad's film, "Freight by Flexi-Van," was shown in three different courses and a film by the General Electric Company, entitled "Millions on the Move," was shown to one course. In addition, the film, "The New Tokaido Line," prepared by the Japanese National Railways, was shown to an audience of about a hundred people. Robert B. Johnston, *chief transit engineer, Delaware River Port Authority,* spoke to Professor Roggeveen's class in transportation planning.

Professor W. W. Hay, *University of Illinois,* reports that the university had the following campus speakers: Maurice N. Quade, *Partner, Parsons, Brinckerhoff, Quade and Douglas, consulting engineers,* who spoke on the subject: "The San Francisco Bay Area Mass Transportation Plan"; Dr. L. K. Sillcox, *honorary chairman of the Board* *and director, New York Air Brake Company,* who spoke on the subject: "Faster Freights"; and ALLEN L. SAMS, *chief engineer, Illinois Central Railroad,* who spoke on the subject: "Modernization of East St. Louis Yard."

Professor Hay, gave a series of three lectures on railroad engineering to the students of the Civil Engineering Department at the University of Colorado. Professor Hay also reported that during the summer of 1964 the Southern Pacific Company and the Pennsylvania Railroad arranged for inspections of portions of their properties for graduate students from the University of Illinois.

On October 8–9, seven AREA members participated in a transportation conference sponsored by the Michigan Technological University at Houghton, Mich. The conference was arranged by FRANK KEREKES, *dean of the faculty, MTU,* and DR. EUGENE Y. HUANG, *professor of transportation, Department of Civil Engineering, MTU,* and covered transportation systems in general and railroad, highway, waterway, airway and piggyback transportation in particular.

In addition to the two faculty members who conducted the sessions, Professor Roggeveen, Stanford University, addressed the conference on "Engineering—Economic Planning of Transport Systems;" FRANK RICHTER, *publisher, Modern Railroads,* gave an illustrated talk on "Modern Trends in Railroad Transportation Systems;" EARL W. HODGKINS, *executive secretary, AREA,* gave an address entitled "Opportunities for Young Engineers in Railroading," before an informal buffet and smoker on the first evening; and A. V. JOHNSTON, *chief engineer, Canadian National Railways, and senior vice president, AREA,* addressed the Conference Dinner on the second evening. His talk was entitled "Railroad Transportation, An International Look". To supplement his talk, Mr. Hodgkins presented the AAR's color, sound motion picture entitled "Science Rides the High Iron."

Professor Hay, University of Illinois, served as master of ceremonies at the Thursday night informal buffet and smoker and JOHN F. DAVISON, *assistant to chief engineer, Canadian National Railways, and chairman of AREA Committee 24—Cooperative Relations With Universities,* served as master of ceremonies at the Conference Dinner on Friday evening.

The conference was arranged by Dean Kerekes, a member of Committee 24, to coincide with the regular fall meeting of that committee, which was held on the MTU campus on October 9–10.

On December 3, WILLIAM B. TITTSWORTH, *office engineer, Western Maryland Railway,* addressed the ASCE student chapter of the University of Maryland on "Civil Engineering Activities in Railroading."

D. H. SHOEMAKER, *chief engineer, Northern Pacific Railway,* gave an illustrated talk before the ASCE student chapter at North Dakota State University on December 10. He discussed various aspects of recent NP engineering projects and showed slides and a motion picture.

R. W. MIDDLETON, *office engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad,* addressed the ASCE student chapter at Marquette University on December 14. Mr. Middleton talked on the opportunities for civil engineers in railroading and on the Milwaukee Road's track-lowering project in tunnels through the Rocky and Cascade Mountains. His talk was illustrated with slides.

In conjunction with their talks, Messrs. Hodgkins, Tittsworth, Shoemaker and Middleton passed out copies of the AREA's Third Edition of the Engineer Recruiting Brochure and folders describing the Association and the Student Affiliate program.

The Pictorial Railroad Exhibit prepared through the efforts of Committee 24 and the executive secretary's office was displayed at the University of Illinois Engineering Open House. Ronald W. Drucker, director of the Railway Section of the Engineering Open House, in a letter to N. D. Howard, then executive secretary, expressed his thanks for Mr. Howard's assistance in making the Railway Exhibit a huge success. The Illinois Central Railroad also cooperated with the University of Illinois Engineering Open House by providing on-track equipment—a locomotive, various types of rolling stock, a rail detector car, a ballast car, an airbrake instruction car, and a model of a highway-crossing flasher signal.

The exhibit also was displayed at the Oregon Museum of Science and Industry, Portland, in connection with a Transportation Club Exhibit from May 1 to September 1, and at the Michigan Technological University, Houghton, Mich., in connection with MTU's Transportation Conference on October 8–10.

Professor B. B. Lewis, *Purdue University,* reports that the senior class of Purdue's School of Civil Engineering included an inspection of a railroad yard during its annual inspection trip to the Chicago area.

E. W. Hodgkins, executive secretary, reports that he is mailing a letter to 63 selected schools advising them of the availability of railroad speakers for addressing their students on their campuses and of the Pictorial Railroad Exhibit. In addition, another letter was mailed to the appropriate deans of about 250 colleges and universities in the United States and Canada informing them of the availability of the Third Edition of the Engineer Recruiting Brochure.

As of October 1, 1964, there were 51 Student Affiliates at 21 different colleges and universities.

Report on Assignment 3

The Cooperative System of Education, Including Summer Employment in Railway Service

W. A. Oliver (chairman, subcommittee), J. B. Babcock, T. P. Cunningham, R. P. Davis, R. J. Fisher, L. J. Hoffman, R. P. Howell, Claude Johnston, E. C. Lawson, B. B. Lewis, J. E. Perry, J. F. Pearce, R. B. Rice, R. W. Ripley, J. A. Rust.

The first reported interest on the part of Committee 24 in the summer employment of engineering students by the railroads will be found in the AREA Proceedings, Volume 50, 1949. The first questionnaire regarding summer employment opportunities was sent to the railroads in 1959. During the intervening ten years, the committee has stimulated railroad interest in the summer employment of engineering students by publishing in its annual report information on the subject obtained in a more or less informal way from both the students who had had the experience and the railroads which had employed them.

Since 1959, a brief but formal questionnaire has been sent to the chief engineering and maintenance officers of the railroads in the United States and Canada in late February requesting information concerning their employment needs for the following summer. As shown in the copy of the questionnaire which is included with this report, some additional information has been requested. However, it has been the purpose of the committee to keep it as simple as possible in order to encourage response. And the response has been consistantly gratifying, with a return of approximately 50 percent, increasing slightly from year to year.

QUESTIONNAIRE ON SUMMER EMPLOYMENT ON THE RAILROADS FOR ENGINEERING STUDENTS —FROM AREA COMMITTEE 24—COOPERATIVE RELATIONS WITH UNIVERSITIES

(Please answer Questions 1, 2, 3 and 4, even though you may not say "yes" to either Questions 5 or 6.)

Name of Railroad ....

Address ....

1. Did you employ engineering or other college students during the summer of 1963 .... If so, how many ....

2. Do you expect to employ students during the summer of 1964 ....

3. Describe briefly the number and types of positions available, and salary ranges

   ....

   ....

   ....

4. Are you willing to have students apply for summer employment along your railroad

   ....

5. If your answer to Question 4 is yes, are you willing to have the committee list the foregoing job opportunities in the information to be sent to the colleges ....

   ....

6. If your answer to Question 5 is yes, may the committee list the names of persons on your railroad to whom application should be made. If so, please furnish names, titles, and addresses ....

   ....

   ....

   ....

Signed ....

Date ....

(Please mail completed questionnaire to W. A. Oliver, Professor of Civil Engineering, University of Illinois, Urbana, Ill., not later than March 6, 1964.)

The summer employment offerings of the railroads as shown on the returned questionnaire have been tabulated, reproduced, and sent to some 125 engineering colleges where they were brought to the students' attention by the college placement officer. As a result of this annual cooperative venture many embryo engineers have obtained their first introduction to railroad work and now some have become permanent employees. Furthermore, the project has shown these young men that there are excellent opportunities for an engineering career in the railway field, thus increasing the interest of the engineering colleges in encouraging this type of employment among their students. Summer employment also gives the railroads an opportunity to observe the boys and determine whether or not they want to offer them employment after they graduate. It should be added that any activity of this kind is in the direction of good public relations.

An examination of the following tabulation will show that the returns from the questionnaire were better in 1964 than they were in 1963. In 1964, 28 railroads indicated that they would offer employment, 16 through Committee 24 and 12 by other means. In 1963, 22 offered summer employment, 17 through Committee 24 and 5 by other means. The total return was larger in 1964 than in 1963. The total return indicates the degree of interest in the program even though employment may not be available.

1964 PROGRAM

Offering employment through Committee 24	16
Offering employment but not through Committee 24	12
Offering employment in 1963 but not in 1964	7
No employment	31
Total return	66

1963 PROGRAM

Offering employment through Committee 24	17
Offering employment but not through Committee 24	5
Offering employment in 1962 but not in 1963	11
No employment	22
Total return	55

As in former reports on this activity it should be stated again that the number of college students given summer employment by the railroads as a result of the Committee 24 project constitutes only a small part of the total number employed. Many railroads have for a long period of time recruited summer employees either directly from the campuses along their properties or through cooperative programs with technical colleges.

Committee 24 wishes to take this opportunity again to thank the railroads for the interest they have shown by helping to carry on this project during the past several years. It plans to continue the program in 1965 and requests their continued cooperation.

Report on Assignment 5

Ways in Which Railroads Can Cooperate with Universities in Developing Research, Including the Revision of "Suggested Topics for Study and Research on Railroad Subjects"

H. E. Hurst (chairman, subcommittee), R. H. Beeder, T. P. Cunningham, R. P. Davis, J. F. Davison, R. J. Fisher, W. W. Hay, L. J. Hoffman, R. P. Howell, Claude Johnston, Frank Kerekes, W. S. Kerr, H. E. Kirby, H. R. Moore, R. B. Rice.

Your committee submits the following report of progress as information.

STUDENT GRANTS

The Engineering Research Division Budget for 1964 includes a Student Research Grant in the amount of $1000, and the same amount has been requested for 1965 to renew the annual fund from which small research grants may be made available to students of universities and colleges to assist them in the development and writing of research reports or theses on railroad engineering subjects.

Although the fund has been established for little more than one year, several students have been authorized grants. It appears that increased activity may now be experienced. It should also be noted that the availability of the funds has promoted interest in railroad subjects even though fund requests did not actually materialize. This is particularly gratifying and, to some extent, an unexpected bonus.

Your committee believes that further interest in railroad subjects may be generated by publishing as a part of the committee's report a listing of student reports or theses which have resulted from the activity of the committee and the availability of the fund. Utilization of the fund would not be a necessary qualification. Any such reports brought to the attention of the committee will receive consideration for the listing.

It is recommended that the assignment be continued.

Report on Assignment 7

Stimulate an Interest by College and University Staff Members in Current Railroad Problems and Practices, Including AREA Membership

W. W. Hay (chairman, subcommitee), R. H. Beeder, J. F. Davison, V. J. Roggeveen, J. L. Alvord, W. S. Autrey, W. R. Bjorklund, J. B. Clark, C. E. R. Haight, C. L. Heimbach, W. H. Huffman, H. E. Kirby, R. C. Nissen, J. A. Peebles, P. S. Settle, Jr.

One of the ways proposed to acquaint academic personnel with the problems and practices of the railroad industry is to make available to them a challenging summer program in the railroad industry. The staff member will in turn take back to the campus an enthusiasm and an understanding of the railroads' problems and potentialities which he will communicate to his students and colleagues. Another advantage lies in making academic personnel more industry-minded and giving them professional alternatives to purely research activities. The purpose of this study is to review some of the possibilities and problems in such a program.

There are several viewpoints concerning the type of employment relationship between the professor and the railroad. The first, and probably the obvious one, is that professorial personnel are useful only in some specific problem areas, primarily on a consulting basis. This has been termed the short-term view. The railroad is interested only in the immediate return it gets from the work done by the professor on the specific problem. There is in turn little opportunity for the staff member to see any more of the railroad operation than is necessary to solve the specific problem at hand. It may involve no real concept of the kinds and magnitude of railroad problems and operations. The cost is usually charged against the department requiring the service.

A second viewpoint, shared by a number of personnel officers of large non-railroad corporations, may be termed the long-term viewpoint. The faculty member is given an assignment within his own field of professional competence, and he makes as much progress as is possible for the period of employment. From this the employer receives certain direct gains and the professor feels he is making a contribution. At the same time the corporation realizes that, because the professor is new both to the corporation and its internal operating procedures, there will be time lost in acquainting the faculty member with the assignment. A certain amount of his time will, therefore, be unproductive. Many industries are willing to charge this time to public relations and to the establishment of good will.

Practical problems arise from the foregoing. First, the railroad people feel that they are more familiar with their own problems than an outsider and that solutions lie within their own organization. On a short-term basis, this is probably true, if they are given the time and money by management to workout the solutions. This attitude overlooks he possibilities that lie in a fresh approach unhampered by tradition. Also, it overlooks the very real expertness that some academic personnel can bring to the railroads' problems.

A second difficulty lies in the reluctance of chief engineers and personnel managers to defend before management the charging of all or part of the professor's time to good will and public relations. This may pose a real problem where the management is not given to innovation in its public relations procedures. Funds for public relations are seldom included in the budgets of railway engineering and maintenance departments.

The outcome of these attitudes, as well as from the failure to recognize the possibilities of such an approach, is seen in a sampling of railroad practice in this regard made within the 21 railroads represented in Committee 24's membership. Of the replies received from 12 of these railroads, 7 said that no college or university staff member was given summer employment. Three made use of faculty members in a conventional consulting relationship, i.e., as experts called in to solve specific problems in soils, geology or general engineering. The usual consulting fees were paid in these instances. One railroad indicated that academic people are employed along with undergraduates making application for summer work to the extent that positions are open but that no planned program or concerted effort had been undertaken. The initiative is thus left to the academic staff member. Payment for services is based on the railroad salary appropriate to the work performed. A Canadian railroad has, in addition to conventional consultation, employed professors from business administration and economics to assist in conducting courses in a six-weeks' staff college. Payment is based on the appropriate railroad salary. Two railroads, including the one mentioned above, have an average of two professors a year on their properties as a part of the Foundation for Economic Development program, to be described later.

Only two replies were received from representatives of the nine universities on the committee. One reply stated that no academic staff member had been employed in the railroad industry during the past five years. The other university representative had enjoyed rather widespread service with several railroads, and from three to six other staff members from his university have served in conventional consulting capacities, especially in the soils area and in research, during the past five years. A neighboring university has had one of its staff serve in a conventional consulting capacity for a northern carrier.

The questionnaire responses seem to be typical of the industry. With a few exceptions to be noted later, the only railroad employment has been that given to a relatively few experts for conventional consultation. There is no organized program to open a broader spectrum of opportunity to professors as a means of acquainting them with the railroad industry.

The value placed by other industries on summer employment of academic personnel is perhaps best expressed in an article that appeared in the *Journal of Engineering Education,* official organ of the American Society for Engineering Education. In the January 1964 issue, pages 191–195, there is an article by C. E. Work of the Michigan Technological University entitled, "Eighth Annual Compilation of the Program for Employing Faculty Members in Industry, Summer 1964." The article states in its opening paragraph:

> "Employment of college faculty members in industry contributes to a better understanding of problems of mutual interest to the institutions educating engineers and scientists and to the companies and agencies who employ their graduates."

The article lists 27 formal programs, a majority of which are in the defense branches of government and related industries. However, the review also lists by name 62 companies, along with the names and addresses of their employing officers, that maintain informal summer employment programs. The list contains outstanding examples of an entire cross-section of American industry but does not contain a single example from the railroad industry.

One other program and point of view is worthy of note because of its well-developed organization and because several railroads are participating in it. This is an orientation program, specifically designed as a public relations effort, to acquaint selected university staff members with the operations, problems and accomplishments of the cooperating industry. As carried out on one mid-western railroad, a total of 22 professors have participated over a 12-year period, including two in the 1964 summer program just ended. About half of these had Ph.D. degrees. They represented 19 different colleges and universities. Three have had two representatives. For the most part the participants have come from on-line schools and most have been in the school of business administration or commerce. A few, however, have come from off-line colleges and universities and other departments such as history, sociology and business English.

The six-weeks' program includes a trip over the line in the general manager's office car thereby enabling the professors to meet and converse with several division officers. There are also visits to and conferences with the officers of the several departments located at the railroad headquarters. There is finally a luncheon and evaluation meeting with the railroad's committee in charge. No productive work is expected from the participants but an "honorarium" of approximately $1000 is paid to cover expenses and to permit, in addition, a little "income" for the participant. No engineering faculty have been included, as the program is sponsored by the Foundation for Economic Development, Inc. There are presently 48 industries cooperating with 57 colleges and universities. Contact for additional information can be accomplished through Dr. W. M. Curtiss, Foundation of Economic Education, Inc., Irvington-On-Hudson, New York, 10533.

The airlines have not been idle in the area of public relations. As one instance, in addition to participating in the foregoing programs, Mohawk Airlines, operating in northeastern United States, has received each year four nominees or fellows whose presence for three-week periods is made possible by four $500 fellowships given to four colleges by the Link Foundation. The colleges receiving the grants name faculty members to participate in the fellowships. The professors are given a three-week viewing of airline properties and daily contact with department heads and other members of management to see how management carries on its business. The last day is devoted in part to reporting back to management by the professors of what they saw and their reactions. Numerous suggestions of value to the airline management have thus been received.

The Ford Foundation has recently established "residencies in engineering practice." These "residencies" cover a period of 15 months. Faculty members spend one year in a firm or company associated with a high-level individual and learn of the decision-making procedures required at that level. No railways have participated in or obtained the benefits of this program. Salaries of the individuals selected for the "residencies" are paid by the company concerned, but the Ford Foundation covers the expense of the interviewing and transportation during the selection process. About 20 nominees are thus employed. It is not difficult to imagine the many times a faculty member thus employed in railroad engineering and maintenance would refer to his new knowledge and experience in his classroom and in planning and carrying out his research program.

One other example, unique with railroads, can be cited. This is the use of a university professor knowledgeable in railroad engineering and maintenance to conduct short courses and give lectures on railroad engineering, i.e., the application of the engineering sciences to the peculiar problems of the railroad industry. The need for these presentations has arisen out of conditions among two types of railroad engineering and maintenance personnel: (1) Those men skilled in railroad practice who have not had the opportunity to learn the engineering principles that give the "why" for what they are doing; and (2) newly employed engineering graduates who had no exposure to the application of engineering principles to railroads during their undergraduate study. It should be noted again that the many demands on the students' time make it impossible for universities to teach more than the fundamentals of engineering. Applications of those principles to a particular industry must be made by that industry itself.

These courses have varied from one day of concentrated presentation on a limited number of subjects to courses of a week's and of two weeks' duration. The reactions of management and "student" alike have been generally favorable. The experience is mutually beneficial. The railroad personnel learn or are refreshed in the application of engineering principles to their work, the engineering reasons for what they do; the instructor in turn is refreshed by the practical aspects of railroad engineering and learns of new procedures and problems. This procedure can be extended to specialized problem areas.

Possible activities in which professorial members may engage, either from the short-term or the long-term point of view, include the following:

a. Conventional consultation—a faculty member called in for assistance on a specific problem.

b. Assignment to research projects in railroad research laboratories, where such laboratories are in use. A research-oriented faculty member might have something to offer to the railroad regardless of the type of problem encountered. The lumber industry, for instance, is doing this very thing and, incidentally, is offering satisfactory salaries.

c. The employee may serve as a full-time consultant during summers or as an assistant to the chief engineer or other high-level officer, providing specialist services and advice in a selected area, such as structures, drainage, soils, track, etc.

d. A problem on which the railroad wishes an answer but on which it does not have ready data may be assigned to the faculty member with the authority to collect and analyze data.

e. The entire system of standards—plans and practices—may be subjected to review and revisions suggested to up date and modernize those plans and practices.

f. The faculty member may fill in on certain jobs while the regular employees are away on vacation.

g. A fertile field is that of programming engineering and operating and maintenance problems for computer solution and otherwise assisting to introduce digital computer methods into these areas.

h. A faculty member especially qualified in mathematics or systems analysis procedures would fit quite readily into almost any industrial engineering department or bureau.

i. Possibly the best entry of faculty members into railroad work, a path that is frequently used in other industries, is through his connection with some kind of research project first sponsored by private industry. In other words, the best way to start a contact and indirect summer employment for a faculty member by railroads is through a research problem. This, then, may branch out into consulting activities and possibly into part-time employment. This approach solves, almost automatically, the problem of "where to put the man and what to do with him."

The problem of financial arrangements has several solutions. These may consist of:

a. "Honorarium-expense" payments for the mere orientation already allude to.
b. Conventional consulting fees.
c. Equivalent railroad salary plus expenses.
d. Equivalent university salary plus expenses.
e. Sponsorship, fellowship or residency through the support of a foundation or trade association program designed for the specific purpose.

A suggestion has been made that the AREA might assist in this program by acting as a clearing house through which railroads could list their needs or opportunities and to which staff members could indicate their interest in having summer employment with a railroad. The AREA could then place the two parties in contact, probably by correspondence or by circular letter.

One other point might well be made which could have considerable bearing on the success or failure of any program undertaken. Providing summer employment for faculty members is not a problem at many schools. In addition to summer school teaching, they have research projects that provide funds for two months of summer work, with the remaining month usually kept free for a vacation.

CONCLUSION

It appears from the foregoing account of relations between colleges and industries that the railroads are missing a significant opportunity to create a sympathetic attitude toward the industry among academic staff.

Report of Committee 18—Electricity

J. J. Schmidt, *Chairman*
F. T. Snider,
Vice Chairman
P. O. Lautz
T. F. Jelnick
H. W. Dunn
E. B. Hager
R. A. Mather
B. C. Hallowell
E. M. Hastings, Jr.
B. Anderhous
R. J. Berti
L. W. Birch
W. F. Bowers
P. R. Broadley
E. H. Brown
G. D. Brown
H. F. Brown
K. A. Browne
P. B. Burley
G. N. Burwell
Robert Burn
N. P. Cain
A. C. Cayou
F. J. Corporon
A. B. Costic
H. C. Cross
L. B. Curtis
D. F. Dunsmore
R. W. Ege
E. D. Feak
H. T. Foy
R. C. Greene
G. B. Hauser
R. E. Hauss
H. C. Held
R. L. Henderson
R. B. Hendrickson
R. H. Holmes
D. R. MacLeod
F. B. McConnel
B. F. McGowan
A. B. Miller
W. O. Muller
J. P. Muelleman
E. L. Musolf
S. R. Negley
K. S. Niemond
R. F. Pownall
J. C. Renfrow, Jr.
E. B. Shew
C. A. Stokes
C. M. Summers
E. L. Tennyson
E. H. Werner
M. I. Yasuna
Committee

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 18.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of AAR Electrical Manual, collaborating with Mechanical Division, AAR.

Progress report, including recommendations with respect to Section 18, submitted for adoption .... page 340

4 and 8. Power supply, motors and controls, collaborating with Mechanical Division, AAR.

No report at this time. A request was received from the Santa Fe Railway that standards be set up for plugs, receptacles and wiring for portable tools and generators, and the committee is planning to undertake such an assignment.

5. Illumination, collaborating with Committee 6 and Mechanical Division, AAR.

Part 1—Lighting Maintenance, presented as information .... page 343

Part 2—Lighting in Piggyback Yards, presented as information .... page 345

9. Electrolysis and electrolytic corrosion, collaborating with Committee 13, and Signal and Communication Section, AAR.

Progress report, presented as information .... page 354

10. Wire, cable and insulating materials, collaborating with Mechanical Division, AAR.
    - A. Wire, Cable and Insulating Standards of Interest to the AREA, presented as information .... page 355
    - B. Report on New Types of Wire, Cable and Insulating Material, presented as information .... page 355
    - C. Revision of AAR Electrical Manual, presented for adoption .... page 356

11. Electric heating, collaborating with Committee 6, and Mechanical Division, AAR.

    Progress report, repesented as information .... page 427

13. Railway electrification, collaborating with Mechanical Division, AAR.

    Progress report, presented as information .... page 428

15. Relations with public utilities, collaborating with Committee 20.

    The committee proposes to send a suitable questionnaire both to AAR Member Roads and to member utilities of the Edison Electric Institute to determine the need for revising the present material on "Crossings of Electrical Supply Lines and Facilities of Steam and Electrified Railroads."

THE COMMITTEE ON ELECTRICTY,
J. J. SCHMIDT, *Chairman.*

AREA Bulletin 590, January 1965.

Report on Assignment 1

Revision of AAR Electrical Manual

Collaborating with Mechanical Division, AAR

P. O. Lautz (chairman, subcommittee), W. O. Muller, Robert Burn, H. W. Dunn, J. J. Schmidt.

Your committee submits for adoption the following recommendations with respect to the AAR Electrical Manual:

SECTION 18—WIRING DIAGRAMS FOR ROLLING STOCK

Change the title of this section to read, "DRAWINGS, SYMBOLS AND ABBREVIATIONS."

Delete Chapter 1—General Index, of Section 18 in its entirety.

[This chapter will become incorrect and unnecessary because the Parts which it indexes will be deleted or reduced and arranged in accordance with the ASA Symbols Index if the other recommendations of your committee with respect to Section 18 are eventually adopted].

Renumber present Chapter 2 of Section 18 as Chapter 1.

[This Chapter should be reviewed by representatives of the collaborating committee with a view to determining definitions, names, and terms for electrical diagrams peculiar to railroad use that are not covered in ASA Standards; then, through proper channels, submitting them to ASA for consideration, looking to approval in ASA Standards, including C42.05 now undergoing revision; or including them in Chapter 2 pending ASA approval, as seems appropriate].

Renumber present Chapter 3, Section 18, as Chapter 2, and change the heading of this Chapter from "SYMBOLS FOR SCHEMATIC WIRING DIAGRAMS" to "GRAPHIC ELECTRICAL SYMBOLS FOR DRAWINGS."

Substitute the following for Part 1 of renumbered and redsignated Chapter 2:

PART 1—GENERAL

1. Graphic symbols for electrical and electronics diagrams shall conform with ASA (American Standards Association) Standard Y32.2, latest revision.

2. Graphic electrical wiring symbols for architectural and electrical layout drawings shall conform with ASA Standard Y32.9, latest revision.

3. Where alternative symbols are shown in ASA Standards, the choice shall be the symbol which is recommended by the IEC (International Electrotechnical Commission). When alternatives still exist, the choice shall be the symbol which historically has been used.

4. When no symbol is listed in ASA Standards to portray a particular device (equipment, item) or function, and when a required symbol cannot be generated by "application" in accordance with ASA Standards, symbols from other national-level standards may be used. Any such symbol, created or used to meet a specific requirement, must be explained on the drawing and shall be reported to the appropriate Division of the AAR. Such symbols shall be given consideration for recommendation toward approval in a revision of or a supplement to ASA Standards and for listing by AAR, pending ASA approval.

5. Contact and switch symbols drawn with circuit terminals or arrows to indicate the contact—but not those drawn with parallel lines to indicate the contact—shall be shown:

   a. With the movable portions to the right or below the fixed portions, when contacts are normally open (NO).
   b. With the movable portions to the left or on top of the fixed portions, when contacts are normally closed (NC).
   c. Connected to agree with the actual electrical arrangement, when the movable portions are hinged.

[Your committee suggests that the statements of Item 5 above, which are a revision of material contained in present Part 1 of Chapter 3, be presented to ASA Committee Y32 for its consideration as a set of basic principles on which certain symbols should be drawn. Such presentation should include the statement that the need for these principles is becoming increasingly important due to the fact that the visual definition or resolution of images on prints made by some methods, which seem to be gaining favor, is not sufficiently distinct to permit determining whether contacts are normally open (NO) or normally closed (NC). This is because adjoining lines tend to "run" together].

Delete entire Part 2—SCHEMATIC WIRING SYMBOLS, from renumbered and redesignated Chapter 2, and substitute the following:

PART 2—LIST OF SYMBOLS

(To be developed)

[When developed, Part 2 will list symbols which are not ASA Standard, and which are created or used and reported in accordance with Paragraph 4 of the foregoing material submitted as new Part 1 of Chapter 3, pending their approval by ASA. The symbols to be inserted here should be developed in collaboration between the Engineering and Mechanical Divisions, AAR; and coordinated with ASA Standards]

Renumber present Chapter 4, Section 18, as Chapter 3, and change the heading of this chapter from "LEAD AND TERMINAL MARKING" to "TERMINAL MARKINGS AND WIRE IDENTIFICATIONS."

Substitute the following for Part 1 of renumbered and redesignated Chapter 3.

PART 1—GENERAL

1. Rotation, connections and terminal markings of electrical apparatus shall conform with ASA Standard C6.1, latest revision, except as hereinafter may be provided for rolling stock or fixed property. The word "terminal" includes lugs and leads.

   a. When no rotation, connection or terminal marking is shown in ASA Standards for a particular electrical apparatus or item of electrical material, any connection, terminal marking, etc., created or used to meet a specific requirement must be explained on the drawing and shall be reported to the appropriate Division of the AAR. Such shall be given consideration for recommendation toward approval in a revision of or a supplement to ASA Standards and for listing by AAR, pending ASA approval.

2. Wires to different connections or terminals from a given connection or terminal shall be separately and specifically identified, and no two such wires shall have the same identification.

Delete Parts 2 and 3 from renumbered and redesignated Chapter 3.

Renumber present Chapter 5, Section 18, as Chapter 4, and change the heading of this chapter from "IDENTIFICATION LETTERS FOR WIRING DIAGRAMS" to "ABBREVIATIONS FOR USE ON DRAWINGS."

Substitute the following for Part 1 of renumbered and redesignated Chapter 4:

PART 1—GENERAL

1. Abbreviations for use on drawings shall be in accordance with ASA Standard Y32.13, latest revision.

2. When no abbreviation is listed in ASA Standards to portray a particular word or expression, and when a required abbreviation cannot be generated in accordance with the basic principles stated in ASA Standards, abbreviations from other national-level standards may be used. Any such abbreviation, created or used to meet a specific requirement, must be explained on the

drawing and shall be reported to the appropriate Division of the AAR. Such abbreviations shall be given consideration for recommendation toward inclusion in revision of ASA Standards and for listing by AAR, pending ASA approval.

[Present Part 1 of present Chapter 5 should be reviewed by representatives of the collaborating committees, appropriately revised and then entered as subsequent part(s) of renumbered Chapter 4].

Renumber present CHAPTER 6—DESIGNATIONS OF SIDES AND ENDS OF LOCOMOTIVES OTHER THAN STEAM AND SELF-PROPELLED CARS, Section 18, as Chapter 5.

Renumber present Chapter 7, Section 18, as Chapter 6, and change the heading of this chapter from "SPECIFICATION FOR SCHEMATIC DIAGRAMS" to "DRAFTING STANDARDS."

Substitute the following for Part 1 of renumbered and redesignated Chapter 6:

PART 1—GENERAL

> Drafting standards shall conform with ASA Standards Y14.1 through Y14.17, latest revisions, except as hereinafter may be provided for rolling stock or fixed property.

Redesignate present Part 1 of present Chapter 7 as Part 2 of renumbered Chapter 6, revising its heading to state that it pertains to rolling stock.

Delete Chapters 8 and 9, Section 18.

[So far as is known to your committee, the specifications in these two chapters are not being used, and have been used by the supply industry only in a general way. It is felt that they have served their purpose and now should be deleted].

Report on Assignment 5

Illumination

Collaborating with Committee 6, and Mechanical Division, AAR

H. W. Dunn (chairman, subcommittee), B. Anderhous, A. C. Cayou, R. L. Henderson, H. T. Foy, R. E. Hauss, E. D. Feak, F. B. McConnel, B. F. McGowan, C. M. Summers.

Part 1—Lighting Maintenance

The object of a lighting system is to provide safe, adequate, and comfortable seeing conditions for a given task. Assuming that the lighting system meets these requirements when new, the next step is proper maintenance to safeguard the effectiveness of the system and the investment in it. Without a good maintenance program, the illumination level may drop to half the designed level in a few months or even weeks. The user is then paying for the watts the system consumes without getting the light he wants.

Maintaining a lighting system involves doing everything necessary to keep the illumination level of the system as near to its initial output as practicable.

Causes of Light Loss

Many factors contribute to light loss, their effect varying with the type of service, type of ventilation, location, type of lamp, type of fixture and lamp-fixture combination. However, the three principal ones are:

1. Dirt on lamps and fixtures.
2. Dirt on room surfaces.
3. Lamp lumen depreciation.

Areas differ as to the amount and type of dirt in the air. For example, the old steam locomotive roundhouse had considerably more and blacker dirt than that found in a diesel locomotive repair shop. Similarly, the dirt in a classification yard near an industrial area differs from that found in a suburban non-industrial area.

1. Dirt on Lamps and Fixtures

The greatest loss of light can usually be attributed to dirt on lamps and fixtures. In a poorly maintained industrial lighting system light losses of 30 percent or more due to dirt accumulation are common. The amount of light lost depends on the kind and amount of dirt in the area. Factors which influence the rate of dirt accumulation include ventilation, lamp type, and fixture finish.

(a) Ventilation Effect

Fixture design affects the rate at which airborne dirt collects. Units with closed tops collect dirt faster than those with ventilated tops. In a ventilated fixture, the temperature difference between the lamp and the surrounding air creates convection currents that carry the dirt past the reflector and the lamp.

(b) Lamp Type

Dirt accumulation on a reflecting surface can be minimized if the reflector is sealed from the air, as in a dust-tight fixture or a reflector-type lamp. Dirt accumulation on a reflector lamp has little or no effect because the reflector is actually sealed inside the glass bulb; also, a new reflector is automatically provided when the lamp is replaced.

(c) Fixture Finishes

Fixture finishes vary in their resistance to dirt accumulation. Processed aluminum finishes, while they do not have as high initial reflectance as enamels, tend to have a slower dirt accumulation rate. Enamels, however, are usually easier to clean. Very often dirt will accumulate on plastic fixture components because of the development of a static charge. Wiping these components may set up such a static charge.

2. Dirt on Room Surfaces

Present-day lighting practices based on room finishes with high reflectance values not only create a pleasant environment but also utilize the light more efficiently. Collection of dirt on these surfaces reduces the reflectance value which in turn reduces the amount of reflected light. This is particularly true with indirect lighting in which even a larger percentage of the light must be reflected by walls and ceilings.

3. Lamp Lumen Depreciation

The light output of lamps decreases the longer they burn. The amount of this reduction in light, called lumen depreciation, depends upon lamp design. Therefore, in the original design of a lighting system careful consideration should be given to the type of lamp selected.

Group Relamping

Light loss due to lamp lumen depreciation can be reduced by group relamping or prompt spot replacement. In some locations it will be necessary to spot-replace lamps to avoid a hazardous condition or for the sake of appearance. In these, and some other locations, spot replacement may prove to be the more economical method. However, the labor costs that can be saved by group relamping an entire lighting system compared to spot replacement usually more than compensates for the value of the depreciated lamps.

Cost studies should be made of each illuminated railroad property site to determine which system of replacement is the most advantageous. Lamp manufacturers have made available cost analysis forms for comparing group relamping with spot relamping. These forms provide data and formulas which will assist the user in determining which system he should be using for his various railroad applications.

Part 2—Lighting for Piggyback Yards

In Section 8—Illumination, of the AAR Electrical Manual, Chapter 2—Lighting of Fixed Property, discusses the fundamental operations carried out in the various types of piggyback yards and gives the footcandle levels of illumination recommended for the various seeing tasks.

In connection with its study of lighting methods in actual use, your committee inspected lighting installations at various piggyback yards. At several of these yards light-meter readings were taken at critical and general illumination areas. The committee has evaluated these various lighting installations and is of the opinion that additional engineering is required to provide better light utilization.

TRAILER-ON-FLATCAR YARDS

The following is a report of the committee's inspection of five trailer-on-flatcar yards in the Chicago area.

Yard 1 (See Figs. 1, 2 and 3)

This is a double yard. One yard has a ramp at the west end, the other at the east end. Each yard has a different type of lighting.

For the yard served by the west ramp, the lighting consists of one row of 250-w white mercury-vapor lamps in open-bottom refractor-type luminaires mounted on steel posts 7 ft above the top of rail. These are centered between two tracks and spaced on 42- and 46-ft centers.

Footcandle readings taken under the front end of one trailer at car-floor level amounted to 6.4 horizontal and 19.0 normal to the light source. Similar readings taken under the rear end of the trailer amounted to 0.4 horizontal and 2.6 normal to the light source.

The yard served by the east ramp consists of two tracks. The south track is lighted by 3-cluster 150-w PAR lamps mounted at a height of 15 ft. Lighting for the north track had not been completed.

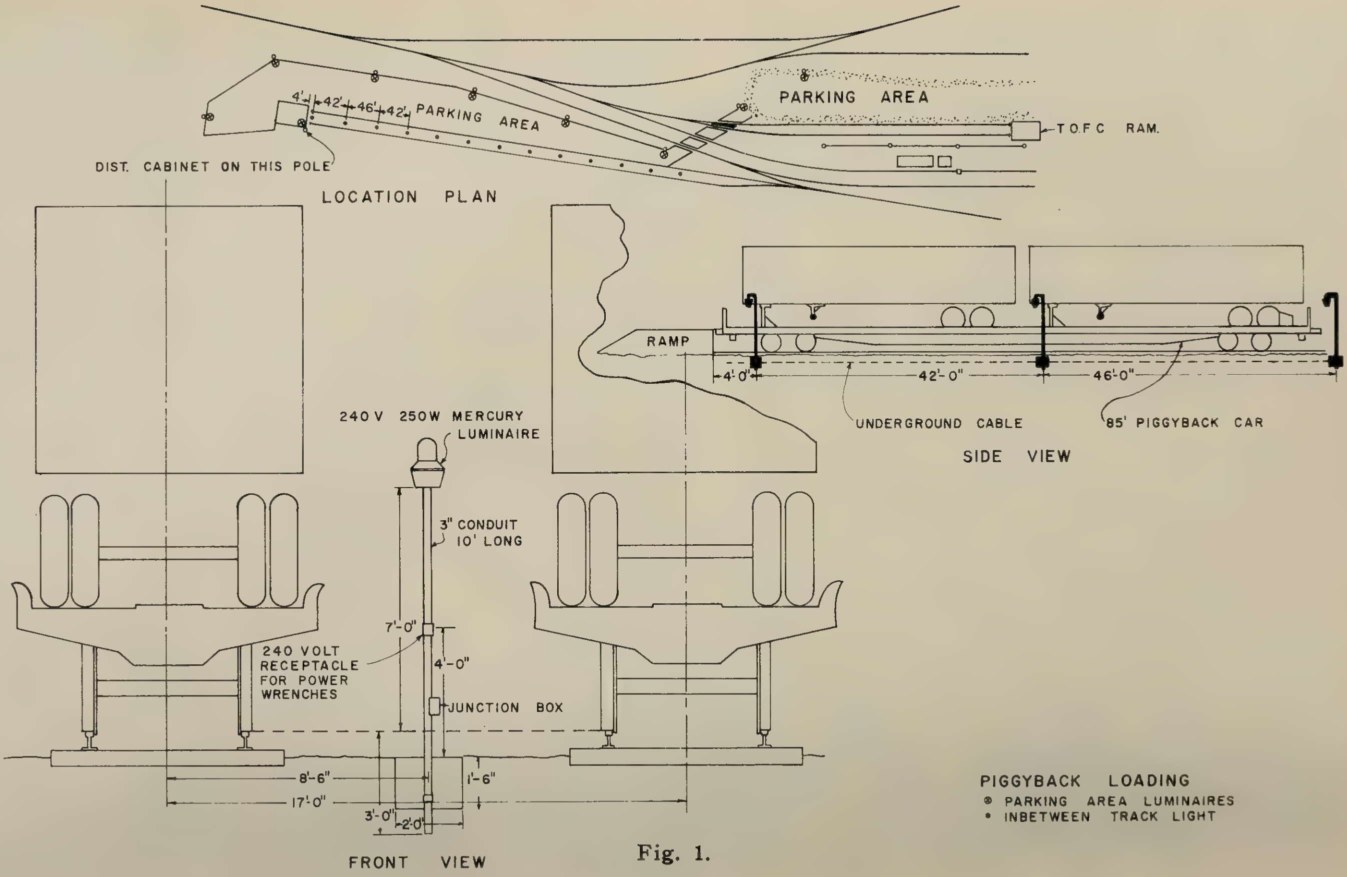

PARKING AREA
T.O.F.C RAM.
4'
42'
46'
42'
PARKING AREA
DIST. CABINET ON THIS POLE
LOCATION PLAN
RAMP
4'-0"
42'-0"
46'-0"
UNDERGROUND CABLE
85' PIGGYBACK CAR
SIDE VIEW
240 V 250W MERCURY LUMINAIRE
3" CONDUIT 10' LONG
7'-0"
240 VOLT RECEPTACLE FOR POWER WRENCHES
4'-0"
JUNCTION BOX
8'-6"
1'-6"
17'-0"
3'-0"
2'-0"
FRONT VIEW
PIGGYBACK LOADING
⊗ PARKING AREA LUMINAIRES
• INBETWEEN TRACK LIGHT

Fig. 1.

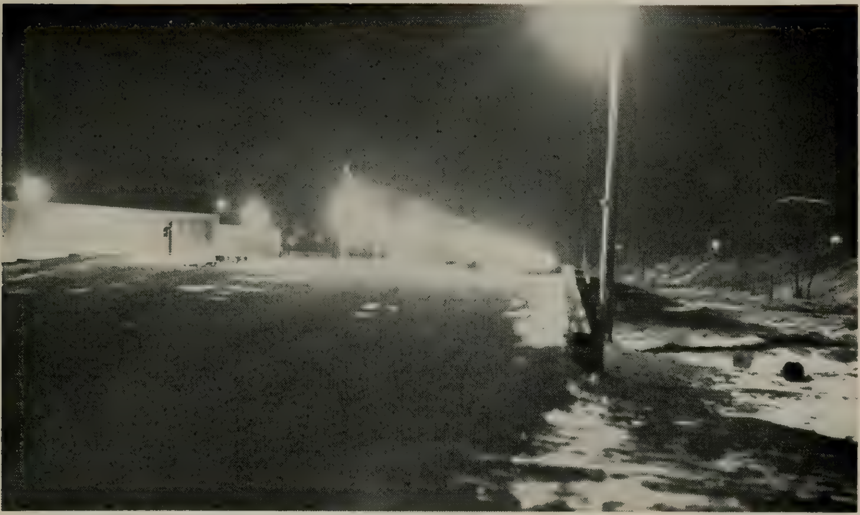


Fig. 2.

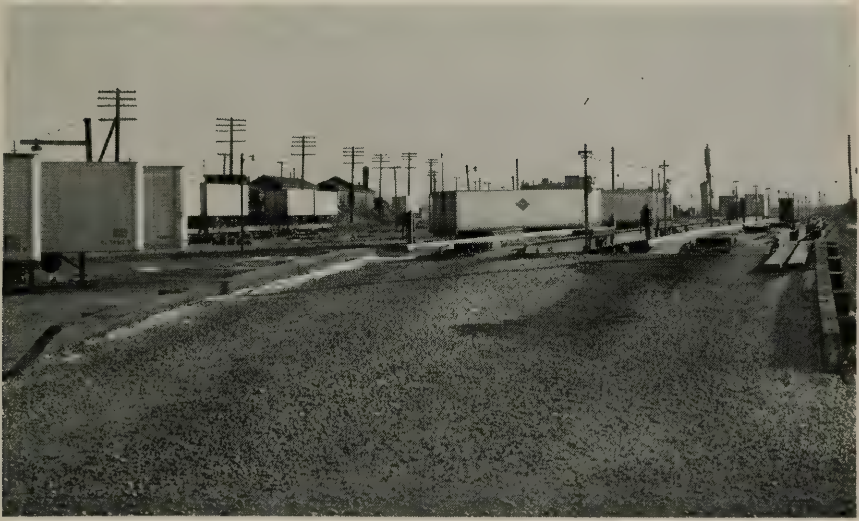


Fig. 3.

Yard 2

This yard consists of five tracks with ramps. Floodlight fixtures with 400-w mercury-vapor lamps mounted 40 to 50 ft high and aimed in a criss-cross pattern provide the illumination.

Yard 3 (See Figs. 4, 5 and 6)

This yard consists of 14 tracks. Illumination is provided by 400–w mercury-vapor lamps in open-bottom refractor-type luminaries mounted on 12-ft steel poles centered between each pair of tracks and spaced 45 ft apart.

Light-meter candlepower readings at two locations were taken, with the following results:

Under front end of trailer, car-floor level:

(a) 4.4 horizontal, 8.7 normal, to light source
(b) 1.4 horizontal, 11.0 normal, to light source

Under rear end of trailer, car-floor level:

(a) Did not register
(b) 1.0 horizontal, 7.0 normal, to light source

Yard 4 (See Figs. 7 and 8)

This yard has 14 tracks. Illumination is provided by single 150-w PAR lamps in enclosed fixtures. They are mounted back to back in pairs 45 ft apart and 18 in above a platform between each pair of tracks. Light mounts are staggered on the platform sides. At the time of installation, the fixtures were aimed to cover tie-down locations under the trailers. Because of various conditions, however, proper aiming is difficult to maintain.

Light-meter readings taken indicated a candlepower of 0.5 horizontal and 5.25 normal to the light source for front ends of trailer at car-floor level.

Yard 5 (See Figs. 9, 10, 11 and 12)

This facility has two ramps, each serving two tracks. Lighting is provided by 300-w incandescent lamps in eliptical open-type floodlight fixtures. These are mounted 8 ft high on steel posts spaced at 50-ft centers. Each row of lights is 10 ft back from the center of the track.

Light meter readings taken indicated a candlepower of 0.8 horizontal and 5.5 normal to the light source for the front ends of trailers at car-floor level.

CONTAINER-ON-FLATCAR YARD

Only one yard of this type was inspected. The illumination for this facility consisted of small sealed-beam automobile lamps mounted on the crane structure 4 ft above ground level. With this type of lighting, it was found that the workmen, while releasing or fastening the containers, blocked out most of the light to the work area. No light-meter readings were taken.

Fig. 13 is a picture of a yard of this type. It is not the one visited, however.

(Text continued on page 354)

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

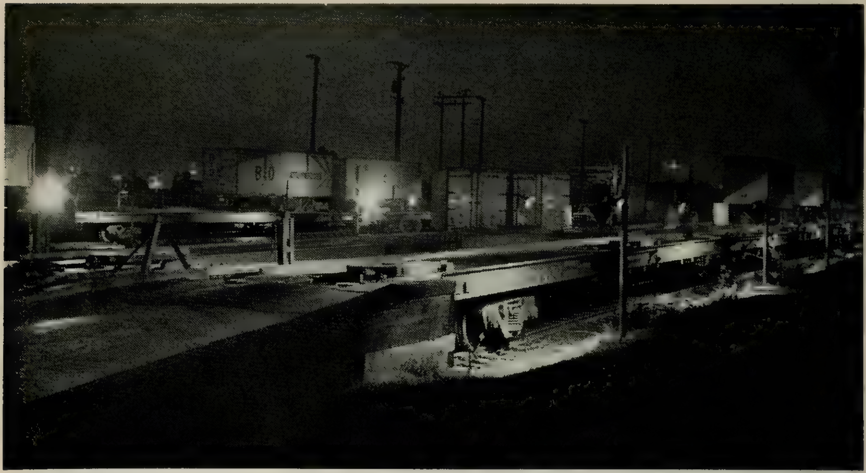


Fig. 10.

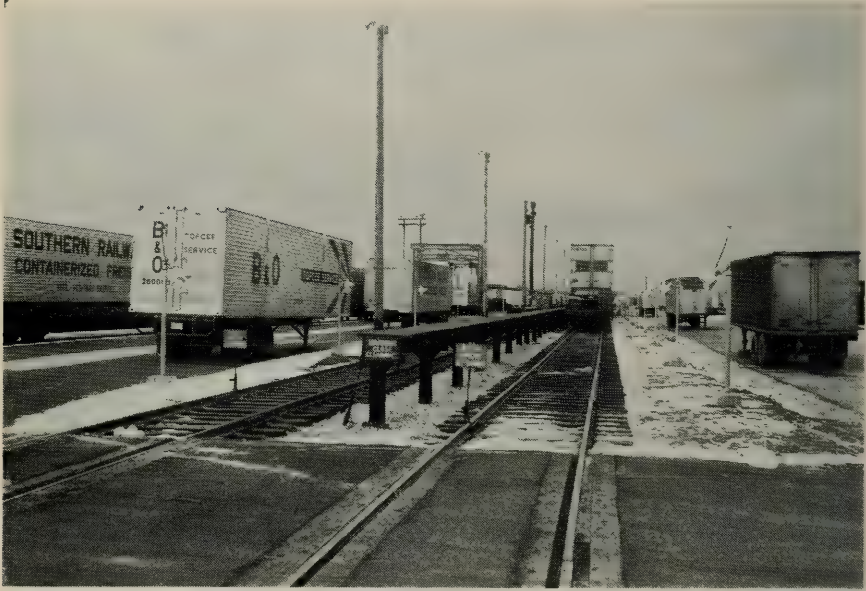


Fig. 11.

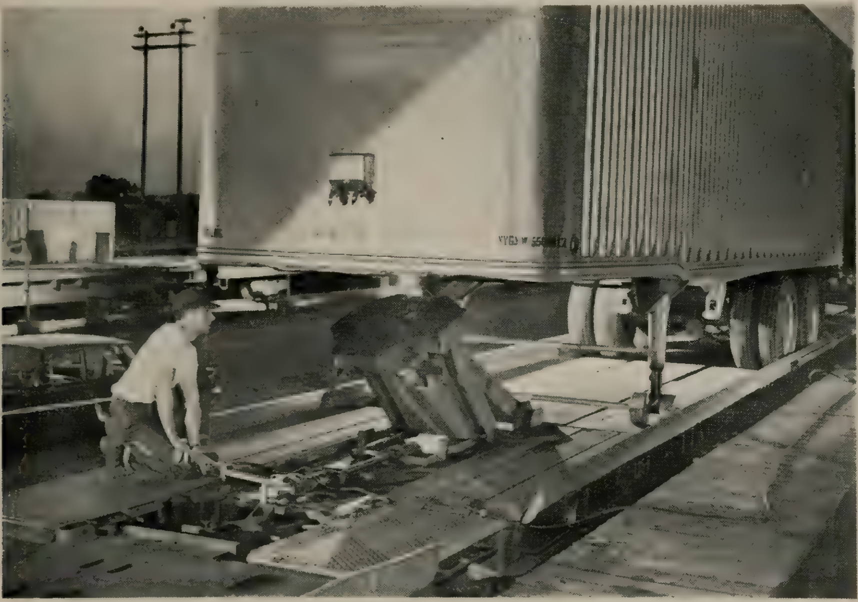


Fig. 12.

Fig. 13.

FLEXI-VAN YARDS

The one yard of this type inspected is illuminated with clusters of three 300-w PAR lamps mounted on poles 30 ft high and 60 ft from the tracks. This system provides general illumination only.

YARDS FOR HANDLING MULTI-LEVEL AUTOMOBILE RACKS

No inspection was made of a yard of this type, but the committee expects to do so and will report its findings at a later date.

SUMMARY

Of the various types of lighting inspected, much can be said both for and against each type. For instance, the use of PAR lamps invites pilferage and malicious damage to the lamps; mercury-vapor lamps are blinding at close range. These particular problems are diminished, of course, if the fixtures are mounted high enough, as for general illumination; but such illumination depends almost entirely on reflected light and does not "spot light" individual work areas.

While each piggyback yard visited was lighted safely and efficiently, an "ideal" installation was not found. Further study is recommended.

Report on Assignment 9

Electrolysis and Electrolytic Corrosion

Collaborating with Committee 13, and Signal and Communication Section, AAR

E. B. Hager (chairman, subcommittee), A. B. Costic, R. H. Holmes, E. H. Werner.

One Aspect of Underground Corrosion of Metallic Structures

This report calls attention to one aspect of failure of underground metallic structures from corrosion and tells how this failure may be delayed or prevented, thus avoiding needless waste. Broadly stated, there are two common classifications of underground corrosion—galvanic corrosion and electrolysis. The classification discussed in this report is galvanic corrosion, which is generated in the earth, destroying exposed metal in the same manner as zinc is destroyed in a flashlight battery during the chemical reaction that produces the current that lights the bulb. Electrolysis is generally understood to mean stray current found in the soil as a by-product of electric traction and is not further discussed here.

When a structure composed of different metals in contact is buried in the earth, corrosion will occur at a rate depending upon the nature of the soil and the ratio of the surface areas of the different metals; also whether the metals are anodic or cathodic to each other. Some metals corrode more readily than others in the same corrosive environment. Some of the common metals and alloys are listed below in their order of corrosivity, starting with the metals that corrode to the greatest extent (anodic or least noble), and ending with those that corrode to the least extent (cathodic or most noble).

Magnesium
Aluminum
Zinc
Cadmium
Iron or steel
Stainless steel (active)
Soft solders
Tin
Lead
Nickel
Brasses
Bronzes
Nickel-copper alloys
Copper
Stainless steel (passive)
Silver
Graphite
Gold
Platinum

Underground use in the same structure of metals or alloys which are farthest apart in the table will result in the greatest destruction of metal, the least noble or anodic metal or alloy suffering the greatest damage. Use of metals near to each other in the table will result in the least destruction. Where it is impossible or undesirable to avoid using metals far apart in the table, damage can be minimized by adjusting the ratio of relatively anodic and cathodic metal.

For example, consider two installations of underground pipe, both in soil of the same resistivity—one consisting of copper or brass pipe to which is added a relatively small amount of steel pipe, the other consisting of steel pipe to which a relatively small amount of copper or brass pipe is added. In the first installation the steel pipe will probably be destroyed relatively fast while in the second, the steel and copper or brass pipe will probably endure for a relatively long time.

Report on Assignment 10

Wire, Cable and Insulating Materials

Collaborating with Mechanical Division, AAR

F. T. Snider (chairman, subcommittee), B. Anderhous, R. Burn, R. C. Greene, P. O. Lautz, R. A. Mather, H. F. Nelson.

Your committee submits its report on wire, cable and insulating materials in three parts. Parts A and B are presented as information; Part C presents revisions to Section 10 of the AAR Electrical Manual, which are recommended for adoption.

A. WIRE, CABLE AND INSULATING STANDARDS OF INTEREST TO THE AREA

Revisions have been made to numerous standards during the past year but the detailed changes are too voluminous to list in this report. The Fourth Edition of "Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy," IPCEA No. S–19–81, NEMA No. WC 3–1963, was issued in January 1964. A new standard on ozone-resisting silicone rubber is being prepared by IPCEA and will be issued in the near future.

B. REPORT ON NEW TYPES OF WIRE, CABLE AND INSULATING MATERIALS

Polytetrafluorethylene

This material was discussed in the 1964 report of this committee. Additional operating experience with this material has revealed certain characteristics which will limit its application to areas where vibration is not present. Trial installations were made on different types of locomotives and car equipment. Six months of operation resulted in several failures of the material due to "cut-through" or abrasion. Vibrating against a rough conduit causes it to be gradually eroded or beaten away until it fails. It is recommended that it be used only in areas where it can be securely fastened and not allowed to vibrate.

Polytetrafluorethylene with a glass braid and the same material with a mineral filler are now being evaluated, and the findings will be given in a future report.

C. REVISION OF AAR ELECTRICAL MANUAL

Your committee recommends for adoption the following recommendations with respect to Section 10 of the AAR Electrical Manual.

Delete Chapters 2, 3 and 4, substituting therefor the following revised material:

PART 2—GENERAL

These specifications provide requirements for the purchase of standard types of wire and cable for use by railroads for new installations and for replacement on existing installations.

Specifications shall be prepared wherever possible in accordance with Part 3.

Where individual specifications contain provisions that differ or conflict with the provisions of specifications of other organizations, the provisions of the individual specification shall govern.

The service for which the individual types are intended are generally indicated in the titles and scopes of these specifications.

Specifications of other organizations referred to as requirements in these specifications shall be an essential part of these specifications except as modified by these specifications.

Number of revisions (revised issues) shall be indicated by a decimal following the specification number.

The latest issue of these specifications supersedes all previous issues.

Wires and Cables manufactured under these specifications are suitable for use on railroads and in other locations where maximum reliability under severe conditions of service is essential.

All workmanship and materials shall be the best of their respective kinds and in full accord with the best engineering practice.

Duplex, Triplex and Twin Cables: The insulated conductors of duplex and triplex cables shall be twisted helically together and suitably filled to provide a cylindrical form in the finished cables. The insulated conductors of twin cable shall be laid parallel and the finished cable shall be flat in form.

Neoprene is a tough, abrasive, oil, moisture and flame resisting synthetic rubber that does not have as good electrical properties as insulation due to its low insulation resistance constant.

In classifying jackets and sheaths in these specifications, the term "jacket" refers to nonmetallic coverings, and "sheath" to continuous metallic coverings.

The wires and cables will be inspected by the designated officer of the railroad or his authorized inspector. The manufacturer shall afford the Inspector every reasonable facility for testing wires and cables purchased under these specifications.

The manufacturer shall notify the inspecting officer sufficiently in advance of the completion of the wires or cables to permit arrangements to be made for the presence of an inspector.

The manufacturer will not be relieved from the responsibility of delivering wires and cables in accordance with these specifications although passed by the inspector.

Unless otherwise specified shipment of cables No. 2 AWG and smaller shall be made in coils or on non-returnable spools, except lead covered cables, which shall be shipped on reels properly lagged or otherwise suitably protected during shipment.

Cables larger than No. 2 AWG shall be shipped on reels properly protected against damage during shipment.

Where reference is made to specifications or methods of test published by the American Standards Association, the American Society For Testing and Materials or other authoritative body, it shall be understood that the reference is to the latest issue of such publication unless otherwise noted.

Standard specifications may be obtained as noted below:

AAR—Copies may be obtained from The Association of American Railroads, 59 East Van Buren Street, Chicago, Ill. 60605

AEIC—Copies may be obtained from the Edison Electric Institute, 10 E. 40th Street, New York, N. Y. 10017

ASA—Copies may be obtained from The American Standard Association, 51 E. 42nd Street, New York, N. Y. 10016

ASTM—Copies may be obtained from The American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103

IPCEA—Copies may be obtained from The Insulated Power Cable Engineers Association, 283 Valley Road, Montclair, N. J.

NEMA—Copies may be obtained from National Electrical Manufacturers' Association, 155 E. 44th Street, New York, N. Y. 10017

The reference IPCEA–NEMA R in these specifications refers to IPCEA–NEMA Publication titled "Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy", IPCEA No. S–19–81 (Fourth Edition), NEMA No. WC3–1964.

PART 3—REQUIREMENTS

General

1. These specifications cover general requirements for single-conductor, multi-conductor belted and multi-conductor non-belted wires and cables insulated with rubber, synthetic rubber, thermoplastic, asbestos, varnished cloth or paper insulation and having any of the usual types of jacket sheath or outer covering, bare and weatherproof wire and cable.

2. These specifications outline the information that should be given in purchase orders or inquiries for wire and cable. Particular attention is called to the need for system and installation data to be furnished in conjunction with the cable data.

Conductors

1. The purchaser shall specify the number, size and shape of conductors in his purchase order.

2. The purchaser shall specify the class of stranding desired in accordance with one of the following specifications.

3. The stranding and material of the conductors shall be in accordance with the following specifications:

a. For bare and weatherproof line wire ASTM B 1, ASTM, B 2, or ASTM B 3.

b. For rubber or asbestos insulated cables: Tinned, or alloy-coated, soft or annealed copper conductors.
For solid conductors: ASTM B 33 or B 189.
For stranded conductors: Individual wires to ASTM B 33 or B 189 and stranding to ASTM B 8.

c. For extra flexible stranding, portable cords, etc., ASTM B 172, ASTM B 173, ASTM B 174.

d. For thermoplastic insulated cables; ASTM B 3 or B 8.

e. For varnished cloth insulated cables: ASA Specification for Varnished Cloth Insulated Cables, C8.13.

f. For paper insulated cables: AEIC Specification for Impregnated Paper Insulated, Lead Covered Cables "Solid Type."

Insulation

1. The purchaser must state the electrical characteristics of his system in order that the minimum recommended thickness of insulation may be determined.

2. The purchaser shall specify the type of insulation desired and also whether non-belted or belted type of cable is to be furnished in accordance with the following specifications.

- a. Rubber Insulation:
  - 1. Heat Resisting Natural Rubber for 75 C Operation: ASTM D 469.
  - 2. Heat Resisting Synthetic Rubber for 75 C Operation: ASTM D 754.
  - 3. Heat and Moisture Resisting Synthetic Rubber for 75 C Operation: ASTM D 1679.
  - 4. Ozone Resisting Butyl Rubber: ASTM D 1352.
- b. Other Types of Insulation:
  - 1. Thermoplastic insulation: ASTM D 734.
  - 2. Varnished cloth insulation: ASA Specification for Varnished Cloth Insulated Cables, C8.13.
  - 3. Paper insulation: AEIC Specification for Solid Type Impregnated Paper Insulated, Lead Covered Cable.
  - 4. Asbestos: ASA C8.36.

Conductor Identification

1. The purchaser shall specify whether or not conductor identification is desired in multi-conductor rubber or thermoplastic insulated cables in accordance with one of the following methods, as specified in IPCEA–NEMA R Standards.

- a. Rubber filled tape on one conductor of each layer.
- b. Cotton braid on one conductor of each layer.
- c. Rubber filled tape on each conductor with a distinctive colored tape on one conductor in each layer.
- d. Cotton braid on each conductor with a raised thread tracer in the braid of one conductor in each layer.
- e. Cotton braid on each conductor, color coded in accordance with the following colored braid code.
- f. Colored thermoplastic with contrasting colored ink stripes.
- g. Thermosetting material (neoprene) in accordance with Method 1, IPCEA-NEMA R, Part 5.
- h. Ridge tracer or tracers.
- i. (See Paragraph 4 under Conductor Assembly).

	Base	*Tracer*	*Tracer*
1.	Black	—	—
2.	White	—	—
3.	Red	—	—
4.	Green	—	—
5.	Orange	—	—
6.	Blue	—	—
7.	White	Black	—
8.	Red	Black	—
9.	Green	Black	—
10.	Orange	Black	—
11.	Blue	Black	—
12.	Black	White	—
13.	Red	White	—
14.	Green	White	—
15.	Blue	White	—
16.	Black	Red	—
17.	White	Red	—
18.	Orange	Red	—
19.	Blue	Red	—
20.	Red	Green	—
21.	Orange	Green	—
22.	Black	White	Red
23.	White	Black	Red
24.	Red	Black	White
25.	Green	Black	White
26.	Orange	Black	White
27.	Blue	Black	White
28.	Black	Red	Green
29.	White	Red	Green
30.	Red	Black	Green
31.	Green	Black	Orange
32.	Orange	Black	Green
33.	Blue	White	Orange
34.	Black	White	Orange
35.	White	Red	Orange
36.	Orange	White	Blue
37.	White	Red	Blue

2. Rubber filled tape shall conform to the following:

   a. Rubber filled tape for all grades of insulation shall be in accordance with IPCEA-NEMA R.

3. Cotton braid, except where used for conductor identification only, shall conform to the requirements of IPCEA-NEMA R, as follows:

   a. Standard braid, (Class B), is designed for indoor service installation in conduits or as the inner braids for multiple conductor cables.

   b. Heavy braid, (Class C), is designed for outdoor and rough service and as the outer braid on multiple conductor cables.

Conductor Assembly

1. Unless otherwise specified in the purchaser's order, two conductor cables shall be of the round type.

2. Flat twin cable may be furnished when specified, where the insulated conductor diameter does not exceed 1-in. Fillers are not required in flat twin cables having an individual conductor diameter of 0.500-in or less.

3. Cables containing two or more conductors, except flat twin cables, shall be cabled with fillers, when needed, to form a compact, cylindrical core.

4. Unless otherwise specified multiple conductor cable assemblies and conductor or circuit identification shall be in accordance with IPCEA-NEMA R, Section 5.1.

Fillers

1. Fillers, where required or used, shall be as follows:

   a. Rubber insulated cable—jute or rubber-like fillers, unless otherwise specified.

b. Thermoplastic insulated cable—jute or treated glass fiber fillers.
c. Varnished cloth insulated cable—jute or twisted paper fillers.
d. Paper insulated cable—twisted paper fillers.

Binder

1. Multi-conductor cables of all types shall be furnished with a suitable binder tape over the cabled core except as modified by the specifications applying to the respective types of cable. Where fillers and jacket are integrated, no binder is necessary.

Shielding

1. Unless otherwise specified, shielding shall be in accordance with IPCEA-NEMA R, Section 4.1. Where shielding required is different than that recommended in any of the specifications referred to herein, such shielding shall be specified by the purchaser on his order. For cables having rated circuit voltages above 2000 volts, strand shielding in accordance with IPCEA-NEMA R, Paragraph 2.3.2 shall be used.

Protective Coverings

1. The customer shall specify which of the following protective coverings is desired.

2. Rubber, thermoplastic or varnished cloth insulated wire or cable may be furnished with any of the following protective coverings:

a. Single cotton braid—See Paragraph 3 under Conductor Identification.
(Applied only on single conductor cable No. 7 AWG and smaller.)
b. Rubber filled tape and cotton braid—See Paragraph 2, and Paragraph 3 under Conductor Identification.
c. Two cotton braids—See Paragraph 3 under Conductor Identification.
d. Rubber filled tape and seine twine braid.
e. Rubber filled tape and jute braid.
f. Asbestos braid.
g. Rubber filled tape and asbestos braid.
h. Rubber filled tape and composite treated glass fiber braid.
i. Rubber filled tape and loom covering. This loom or woven covering of soft cotton hose cord resembles a woven fire hose. The loom shall be closely woven and its construction shall conform to the following table.

LOOM COVERING

Size and Ply of Cotton and Picks per Inch

Dia. Over Core (In.)	Hose Cord Size and Ply	Min. Picks per In.
0–0.900	8–8	8
.901–1.500	8–12	8
1.501 and over	8–20	7

For "Flat Twin," construction the core diameter shall be that corresponding to the major axis.

j. Lead sheath, on rubber, or varnished cloth insulated cable, shall be in accordance with the requirements for lead sheath as contained in IPCEA–NEMA R.

k. Alloy lead sheath, or rubber, or varnished cloth insulated cable shall be of a composition as agreed upon between the user and supplier for the particular application concerned.

3. Black neoprene jacket on rubber insulated cables shall meet the requirements of ASTM D 752.

4. Natural rubber jacket on rubber insulated cables shall be a tough, abrasion resisting sheath meeting the requirements of ASTM D 532.

5. S.B.R. rubber jacket on rubber insulated cables shall be a tough abrasion resisting sheath meeting the requirements of ASTM D 866.

6. Thermoplastic jacket for thermoplastic-insulated conductor assemblies shall be in accordance with IPCEA–NEMA R, Paragraph 4.13.5 for polyvinylchloride, or 4.13.6 for polyethylene.

7. Paper insulated cables shall be furnished with lead sheath in accordance with the requirements of the AEIC Specification for solid type Impregnated Paper Insulated, Lead Covered Cable. Alloy lead sheath, as outlined in Paragraph 2k above, shall be furnished in accordance with the AEIC Specification when specified on the order.

Saturant and Finish

1. When one of the fibrous coverings of paragraph 2—Protective Coverings is specified by the purchaser, a type of saturant and finish or paint finish, also should be specified for application to the braid or loom covering. In all cases the finished wire or cable shall meet the melting and dripping tests outlined in ASTM D 470.

2. The saturant and finish used in the braid or loom covering shall be in accordance with one of the following sections. The finished wire or cable shall meet the requirements of ASTM D 1350, Sections 18 through 21 for indoor braids, or Sections 22 through 27 for outdoor braids.

a. Flame and Moisture Retarding Finished Braid.

A saturant consisting of an asphaltic base material or an asphaltic base material blended with suitable high melting point waxes, but in neither case shall any volatile materials such as paraffin, scale wax, wax tailings or flux oils be added. Saturation shall be so thorough that no white or unsaturated ends of fiber will be exposed by a diagonal cut through the covering.

The saturated braid or loom covering of the cable shall be finished with a dark colored flexible coating material, such as stearine pitch or high softening point asphalt and coated with mica flake.

b. Moisture-Retarding Smooth, Black Finished Braid.

A saturant consisting of an asphaltic base material or an asphaltic base material blended with suitable high melting point waxes, but in neither case shall any volatile materials such as paraffin, scale wax, wax tailings or flux oils be added. Saturation shall be so thorough that no white or unsaturated ends of fiber will be exposed by a diagonal cut through the covering.

The saturated braid or loom covering of the cable shall be finished with black wax or bituminous compound to provide a smooth black finish.

3. Paint Filled and Finished Braid.

The braid or loom covering shall be filled with a suitable slow burning paint. The covering shall be coated with a finishing compound of a similar type. Grey or drab shall be the standard color for slow burning finish and will be furnished unless black or white is specified by the purchaser.

Armor

1. When specified by the purchaser, metallic armor, as outlined below, shall be furnished in accordance with ASA Specification C8.15.

   a. Flat steel tapes.
   b. Flat non-magnetic tapes.
   c. Interlocking steel tapes.
   d. Interlocking non-magnetic tapes.
   e. Galvanized steel or non-magnetic wire armor.

2. When specified by the purchaser, non-metallic armor shall be furnished in accordance with IPCEA–NEMA R, Paragraph 4.13.3.

Outer Protective Covering

1. When specified by the purchaser, protective covering may be applied over metallic sheath or armor, in accordance with IPCEA–NEMA R, Part 4, as follows:

   a. Adhesive cement where required, vulcanized Neoprene tapes with or without reinforcing and lubricant.
   b. Jute serving and asphalt with mica or soapstone finish.
   c. Asbestos braid in accordance with ASA C8.36.
   d. Extruded polyvinylchloride.
   e. Extruded polyethylene.
   f. Extruded neoprene.

Identification

1. The wires and cables shall be identified by Manufacturers Electrical Code Marker or Manufacturers Name Tape.

PART 4—DETAILED SPECIFICATIONS

Specification No. 501

Specification for No. 18 AWG to 2,000,000 CM, Bare Soft Annealed Copper Wire and Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding:	
No. 18 AWG to No. 5 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class A
Packing for Shipment:	
Stranded Conductors	On reels
Solid Conductors:	
No. 1 AWG and larger	On reels
No. 2 AWG to No. 14 AWG, Incl.	Coils
Other Sizes	Spools

Packing for Shipment:

(a) Diameter of the eye of the coil shall be not less than 14 inches nor more than 22 inches.

(b) Each coil shall be suitably bound with two ply weatherproof crepe paper, overlapping not less than one-half its width.

(c) Each coil or reel shall have the weight, length, size of wire, name of the manufacturer, Railroad's order and requisition numbers and the proper shipping address plainly and indelibly marked on two strong tags. One of these tags shall be attached to the coil inside the paper wrapping and the other shall be attached to the coil outside the paper wrapping.

Specification No. 502.1

Specification for No. 14 AWG to 2,000,000 CM, Bare Hard and Medium Hard Drawn Copper Wire and Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Hard Drawn Copper	ASTM B 1
Medium Hard Drawn Copper	ASTM B 2
Stranding:	
No. 14 AWG to No. 5 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class A
Packing for Shipment:	
Stranded Conductors	On reels
Solid Conductors:	
No. 1 AWG and larger	On reels
No. 2 AWG to No. 14 AWG, Incl.	Coils
Other Sizes	Spools

Packing for Shipment:

(a) Diameter of the eye of the coil shall be not less than 14 inches nor more than 22 inches.

(b) Each coil shall be suitably bound with two ply weatherproof crepe paper, overlapping not less than one-half its width.

(c) Each coil or reel shall have the weight, length, size of wire, name of the manufacturer, Railroad's order and requisition numbers and the proper shipping address plainly and indelibly marked on two strong tags. One of these tags shall be attached to the coil inside the paper wrapping and the other shall be attached to the coil outside the paper wrapping.

Specification No. 503.2

Specification for No. 14 AWG to 2,000,000 CM, Hard and Medium Hard Drawn Triple Braided Weatherproof Wire and Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Hard Drawn Copper	ASTM B 1
Medium Hard Drawn Copper	ASTM B 2
Stranding:	
No. 14 AWG to No. 4 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class A
Braids	ASA C8.18
Packing for Shipment:	
Stranded Conductors	On reels
Solid:	
No. 1 AWG and larger	On reels
Other sizes	Coils

Packing for Shipment:

(a) Diameter of the eye of the coil shall be not less than 14 inches nor more than 22 inches.

(b) Each coil shall be suitably bound with two ply weatherproof crepe paper, overlapping not less than one-half its width.

(c) Each coil or reel shall have the weight, length, size of wire, name of the manufacturer, Railroad's order and requisition numbers and the proper shipping address plainly and indelibly marked on two strong tags. One of these tags shall be attached to the coil inside the paper wrapping and the other shall be attached to the coil outside the paper wrapping.

Specification No. 504.2

Specification for No. 14 AWG to 2,000,000 CM, Hard and Medium Hard Drawn Triple Knitted Braid Weatherproof Wire and Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Hard Drawn Copper	ASTM B 1
Medium Hard Drawn Copper	ASTM B 2
Stranding:	
No. 14 AWG to No. 4 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class A
Braids	ASA C8.18
Packing for Shipment:	
Stranded conductors	On reels
Solid:	
No. 1 AWG and larger	On reels
Other sizes	Coils

Packing for Shipment:

(a) Diameter of the eye of the coil shall be not less than 14 inches nor more than 22 inches.

(b) Each coil shall be suitably bound with two ply weatherproof crepe paper, overlapping not less than one-half its width.

(c) Each coil or reel shall have the weight, length, size of wire, name of the manufacturer, Railroad's order and requisition numbers and the proper shipping address plainly and indelibly marked on two strong tags. One of these tags shall be attached to the coil inside the paper wrapping and the other shall be attached to the coil outside the paper wrapping.

Specification No. 505.2

Specification for No. 12 AWG to 500,000 CM, Hard and Medium Hard Drawn, Neoprene Weatherproof Wire and Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Hard Drawn Copper	ASTM B 1
Medium Hard Drawn Copper	ASTM B 2
Stranding:	
No. 12 AWG to No. 4 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class A
Covering	Neoprene, ASA C8.34
Finish	See Paragraph 1
Packing for Shipment:	See Paragraph 2
Stranded conductors	On reels
Solid:	
No. 1 AWG and larger	On reels
Other Sizes	Coils

1. Finish:

A coating of paraffin, powdered soapstone, mica or other suitable lubricant may be applied to facilitate installation.

2. Packing for Shipment:

(a) Diameter of the eye of the coil shall be not less than 14 inches nor more than 22 inches.

(b) Each coil shall be suitably bound with two ply weatherproof crepe paper, overlapping not less than one-half its width.

(c) Each coil or reel shall have the weight, length, size of wire, name of the manufacturer, Railroad's order and requisition numbers and the proper shipping address plainly and indelibly marked on two strong tags. One of these tags shall be attached to the coil inside the paper wrapping and the other shall be attached to the coil outside the paper wrapping.

Specification No. 507.2

Specification for Single Conductor No. 18 AWG to 2,000,000 CM, Rubber Insulated, Braided Cable, 0–600 Volt, for Indoor Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation:	
No. 18 AWG and No. 16 AWG	3/64-Tolerance IPCEA-NEMA R
Other sizes	IPCEA-NEMA R
Protection Over Insulation:	
No. 8 AWG and smaller	None
Other sizes	IPCEA-NEMA R, Tape or Braid
Braid Covering	IPCEA-NEMA R—Standard Braid
Saturant and Finish	IPCEA-NEMA R—Indoor Use

Specification No. 508.2

Specification for Single Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Braided Cable, 601–1000 Volt, for Indoor Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
No. 8 AWG and smaller	None
Other sizes	IPCEA-NEMA R, Tape or Braid
Braid Covering	IPCEA-NEMA R, Standard Braid
Saturant and Finish	IPCEA-NEMA R, Indoor Use

Specification No. 510.2

Specification for Single Conductor No. 10 AWG to 2,000,000 CM, Rubber Insulated, Braided Cable, 2001–3000 Volt, for Indoor Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
No. 8 AWG and smaller	None
Other sizes	IPCEA-NEMA R, Tape or Braid
Braid Covering	IPCEA-NEMA R, Standard Braid
Saturant and Finish	IPCEA-NEMA R, Indoor Use

Specification No. 531.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Lead Sheathed Cable, 0–600 Volt, for General Service

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Insulation:	
Heating Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R
Protection Over Core	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R

Specification No. 532.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Lead Sheathed Cable, 601–1000 Volt, for General Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R
Protection Over Core	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R

Specification No. 534.2

Specification for Single and Multiple Conductor No. 10 AWG to 2,000,000 CM, Rubber Insulated, Lead Sheathed Cable, 2001–3000 Volt, for General Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R
Protection Over Core	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R

Specification No. 535.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 0–600 Volt, for Direct Burial, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
Single Conductor	None
Multiple Conductor	IPCEA-NEMA R, Tape or Braid
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 536.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 601–1000 Volt, for Direct Burial, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
Single Conductor	None
Multiple Conductor	IPCEA-NEMA R, Tape or Braid
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 538.2

Specification for Single and Multiple Conductor No. 10 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 2001–3000 Volt, for Direct Burial, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
Single Conductor	None
Multiple Conductor	IPCEA-NEMA R, Tape or Braid
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 539.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 0–600 Volt, for Direct Burial, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
Single Conductor Cable	None
Multiple Conductor Cable	IPCEA-NEMA R, Part 4, General Purpose Neoprene
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 540.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 601–1000 Volt, for Direct Burial, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
Single Conductor Cable	None
Multiple Conductor Cable	IPCEA-NEMA R, Part 4, General Purpose Neoprene
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 542.2

Specifications for Single and Multiple Conductor No. 10 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 2001–3000 Volt, for Direct Burial, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation:	
Single Conductor Cable	None
Multiple Conductor Cable	IPCEA-NEMA R, Part 4, General Purpose Neoprene
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 543.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Lead Sheathed Parkway Cable, 0–600 Volt, Armored with Ungalvanized Flat Steel Tapes.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 544.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Lead Sheathed Parkway Cable, 601–1000 Volt, Armored with Ungalvanized Flat Steel Tapes.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor.	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 546.2

Specification for Single and Multiple Conductor No. 10 AWG to 2,000,000 CM, Rubber Insulated, Lead Sheathed Parkway Cable, 2001–3000 Volt, Armored with Ungalvanized Flat Steel Tapes.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 547.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed, Lead Sheathed Parkway Cable, 0–600 Volt, Armored with Galvanized Flat Steel Tapes.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductors:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 548.2

Specification for Single and Multiple Conductor No. 14 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed, Lead Sheathed Parkway Cable, 601–1000 Volt, Armored with Galvanized Flat Steel Tapes.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductors:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 550.2

Specification for Single and Multiple Conductor No. 10 AWG to 2,000,000 CM, Rubber Insulated, Neoprene Jacketed, Lead Sheathed Parkway Cable, 2001–3000 Volt, Armored with Galvanized Flat Steel Tapes.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductors:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and No. 10 AWG	Solid
Other Sizes	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 555.2

Specification for Single Conductor No. 8 AWG to 500,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 4001–5000 Volt, for Pole Riser and Duct Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Shielding	IPCEA-NEMA R
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 556.2

Specification for Multiple Conductor No. 8 AWG to 500,000 CM, Rubber Insulated, Neoprene Jacketed Cable, 4001–5000 Volt, for Duct and Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape
Shielding	IPCEA-NEMA R
Cable Assembly	IPCEA-NEMA R, Round
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty

Specification No. 557.2

Specification for Single Conductor No. 8 AWG to 500,000 CM, Rubber Insulated, Lead Sheathed Cable 4001–5000 Volt, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape
Lead Sheath	IPCEA-NEMA R

1. Lead Sheath

Lead-alloy sheath should be used where excessive vibration is present.

Specification No. 558.2

Specification for Multiple Conductor No. 8 AWG to 500,000 CM, Rubber Insulated, Lead Sheathed Cable, 4001–5000 Volt, Duct or Aerial Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class B
Strand Shielding	IPCEA-NEMA R, Part 2
Insulation:	
Ozone Resisting Butyl Rubber	IPCEA-NEMA R, Part 3
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape
Cable Assembly and Form	IPCEA-NEMA R, Round
Lead Sheath	IPCEA-NEMA R

1. Lead Sheath

Lead-alloy sheath should be used where excessive vibration is present.

Specification No. 559.2

Specification for Single and Multiple Conductor No. 14 AWG to 500,000 CM, Rubber Insulated, Lead Sheathed Submarine Cable, 0–600 Volt, Round Steel Armored.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
No. 8 AWG and smaller	Solid
Other Sizes	ASTM B 8, Class B
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	IPCEA-NEMA R
Protection Over Insulation	IPCEA-NEMA R, Tape or Braid
Protection Over Assembly	IPCEA-NEMA R
Lead Sheath	IPCEA-NEMA R
Armoring and Outer Covering	IPCEA-NEMA R

Specification No. 560.2

Specification for Multiple Conductor No. 18 AWG to No. 10 AWG Type SO, Heavy Duty, and Multiple Conductor No. 18 AWG and No. 16 AWG Type SJO, Light Duty Portable Cords.

Component Parts	*Specification Requirements*
Size and Number of Conductors	As specified in the order
Type	As specified in the order
Material of Conductors:	
Soft annealed copper	ASTM B 3
Stranding	ASTM B 174, Class K, through Class O, and with lay per Column B of Table II
Separator	IPCEA-NEMA R
Working Voltage:	
No. 18 AWG and No. 16 AWG Type SJO	0–300
No. 18 AWG to No. 10 AWG, Incl., Type SO	0–600
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat Resisting Synthetic Rubber	ASTM D 754
Thickness of Insulation	IPCEA-NEMA R

Specification No. 560.2—Continued

Component Parts	*Specification Requirements*
Assembly	IPCEA-NEMA R, Part 7
Neoprene Jacket	IPCEA-NEMA R, Part 4
Thickness of Jacket	IPCEA-NEMA R, Part 7
Overall Diameter	IPCEA-NEMA R, Part 7
Electrical Test of Completed Cord	IPCEA-NEMA R, Part 7
Shipping Lengths and Packing	See Paragraph 2

1. Scope

This specification describes a light duty and a heavy duty cord for extension service for instrument, meter, lamp or tool operation.

2. Shipping Lengths and Packing

The cable shall be delivered in coils of approximately 500 feet provided that such coils do not weigh more than 200 lb. When the weight is over 200 lb. the wire shall be shipped on reels. Twenty percent of the coils will be accepted if 200 feet or over. No coil shall be less than 100 feet in length, except where a coil submitted for inspection and testing has been cut to secure a sample for testing.

Both ends of every coil or reel shall be accessible. The inside diameter of the coil shall be not less than seven inches. Every coil shall be securely bound with strong tape in at least four separate places and shall then be wrapped in burlap or strong paper so as to avoid mechanical injury during transportation.

Each coil or reel shall have two strong tags securely fastened, one to the inside, the other to the outside of the coil or reel. The tags shall be plainly and indelibly marked to show the Manufacturer's name, the gauge of the conductors, the number of strands, the number of conductors, the overall diameter, the number of this specification (560.2) and the Railroad's order and requisition numbers.

Specification No. 562.2

Specification for Multiple Conductor No. 8 AWG to 500,000 CM, Extra Flexible Type W, 0–600 Volt, Portable Power Cable.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductors:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 173, Class H
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat Resisting Synthetic Rubber	ASTM D 754
Thickness of Insulation	IPCEA-NEMA R
Conductor Identification	IPCEA-NEMA R
Cable Assembly Fillers and Binders:	
2-Conductor No. 4/0 AWG and Smaller	IPCEA-NEMA R, Flat
All Others	IPCEA-NEMA R, Round
Neoprene Jacket	IPCEA-NEMA R, Part 7, Extra Heavy Duty
Thickness of Jacket	IPCEA-NEMA R, Part 7
Overall Diameter	IPCEA-NEMA R
Electrical Tests	IPCEA-NEMA R, Part 7

Scope

This specification describes extra heavy duty neoprene jacketed Type W portable power cable for use in furnishing power to portable machine tools. The conductors are all insulated, one of which may be used as a ground wire. For a similar type of cable using non-insulated ground wires in addition to the insulated conductors (see Spec. No. 563.2.)

These cables are suitable for battery charging and standby service where the installation is protected by planks, ducts, etc.

Specification No. 563.2

Specification for Multiple Conductor No. 8 AWG to 500,000 CM, Extra Flexible Type G, 0–600 Volt, Portable Power Cable

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductors:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding:	
Power Conductors	ASTM B 173, Class H
Grounding Conductors	IPCEA-NEMA R
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat Resisting Synthetic Rubber	ASTM D 754
Thickness of Insulation	IPCEA-NEMA R
Conductor Identification	IPCEA-NEMA R
Cable Assembly, Fillers and Binder:	
2-Conductor No. 4/0 AWG and Smaller	IPCEA-NEMA R, Flat
All Others	IPCEA-NEMA R, Round
Neoprene Jacket	IPCEA-NEMA R, Part 7, Extra Heavy Duty
Thickness of Jacket	IPCEA-NEMA R
Overall Diameter	IPCEA-NEMA R
Electrical Tests	IPCEA-NEMA R

Scope

This specification describes extra heavy duty neoprene jacketed Type G portable power cable for use in furnishing power for portable machine tools. Nonsulated ground wires are furnished in addition to the insulated conductors (See Spec. 562.2).

Specification No. 564.1

Specification for Single Conductor No. 14 AWG to 2,000,000 CM, Varnished Cloth Insulated, Lead Sheathed Cable, 0–600 Volt, for General Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding:	
No. 14 AWG to No. 8 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Insulation 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Lead Sheath and Thickness	ASA C8.13

Scope

This specification describes varnished cloth insulated and lead sheathed cable for 0–600 Volt for general service. It is not recommended for direct burial unless the lead sheath is protected by a covering in accordance with the armored coverings of ASA C8.15.

Specification No. 565.1

Specification for Multiple Conductor No. 14 AWG to 500,000 CM, Varnished Cloth Insulated, Lead Sheathed Cable, 0–600 Volt, for General Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding:	
No. 14 AWG to No. 8 AWG, Incl.	Solid
Other Sizes	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Assembly 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Cable Assembly and Form	Round, ASA C8.13
Lead Sheath and Thickness	ASA C8.13

Scope

This specification describes varnished cloth insulated and lead sheathed cable for 0–600 Volt for general service. It is not recommended for direct burial unless the lead sheath is protected by a covering in accordance with the armored coverings of ASA C8.15.

Specification No. 566.1

Specification for Single Conductor No. 8 AWG to 2,000,000 CM, Varnished Cloth Insulated, Lead Sheathed Cable, 4001–5000 Volt, (Grounded Neutral) for Duct Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Insulation 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Lead Sheath and Thickness	ASA C8.13

Scope

This specification describes varnished cloth insulated, lead sheathed cable for 4001–5000 Volt (Grounded Neutral) for Duct Service. The range of sizes in this specification starts at No. 8 AWG because the manufacturers do not recommend varnished cloth insulation at this voltage on smaller sizes.

Specification No. 567.1

Specification for Multiple Conductor No. 8 AWG to 500,000 CM, Varnished Cloth Insulated, Lead Sheathed Cable, 4001–5000 Volt, (Grounded Neutral) for Duct Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Assembly 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Cable Assembly and Form	Round, ASA C8.13
Lead Sheath and Thickness	ASA C8.13

Scope

This specification describes varnished cloth insulated, lead sheathed cable for 4001–5000 Volt (Grounded Neutral) for Duct Service. The range of sizes in this specification starts at No. 8 AWG because the manufacturers do not recommend varnished cloth insulation at this voltage on smaller sizes.

Specification No. 568.1

Specification for Multiple Conductor No. 6 AWG to 500,000 CM, Varnished Cloth Insulated, Lead Sheathed Cable, 11001–12000 Volt, (Grounded Neutral) for Duct Service.

Component Parts	*Specification Requirements*
Size and Number of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Insulation 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Cable Assembly and Form	Round, ASA C8.13
Lead Sheath and Thickness	ASA C8.13

Scope

The range of sizes in this specification starts at No. 6 AWG because the manufacturers do not recommend varnished cloth insulation at this voltage on smaller sizes.

Specification No. 569.2

Specification for Single Conductor No. 6 AWG to 500,000 CM, Varnished Cloth Insulated, Braided Cable, 11001–12000 Volt, (Grounded Neutral) for Indoor Station Service.

Component Parts	*Specification Requirements*
Size of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Insulation 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Braid Covering	Heavy Braid, ASTM D 1350
Saturant and Finish	See Paragraph 2

1. Scope

This specification describes varnished cloth insulated and gray paint flameproof braided cable, 11001–12000 Volt, (Grounded Neutral) for indoor station service.

2. Saturant and Finish

The braid covering shall be filled with a suitable slow burning paint. The covering shall be coated with a finishing compound of a similar type. Gray or drab shall be the standard color for slow burning finish and will be furnished unless black or white is specified in the order.

Specification No. 570.1

Specification for Single Conductor No. 6 AWG to 500,000 CM, Varnished Cloth Insulated, Lead Sheathed Cable, 11001–12000 Volt, (Grounded Neutral) for Duct Service.

Component Parts	*Specification Requirements*
Size of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper	ASTM B 3
Stranding	ASTM B 8, Class B
Insulation and Thickness:	
Varnished Cloth	ASA C8.13
Protection Over Insulation:	
Diameter of Cable Over Insulation 1″ or less	None
Other Sizes	Cable Tape, ASA C8.13
Lead Sheath and Thickness	ASA C8.13

Specification No. 572

Specification for Triplex No. 4 AWG to 500,000 CM, Paper Insulated, 4001–5000 Volt, (Grounded Neutral) Lead Sheathed Cable, NonShielded Type.

Component Parts	*Specification Requirements*
Size of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, bare	ASTM B 3
Stranding:	
Compact Sector	AEIC Specifications—Solid Type
Insulation and Thickness	AEIC Specifications—Solid Type
Belt and Thickness	AEIC Specifications—Solid Type
Lead Sheath and Thickness	AEIC Specifications—Solid Type

Specification No. 573

Specification for Triplex No. 4 AWG to 500,000 CM, Paper Insulated, 11001–12000 Volt, (Grounded Neutral) Lead Sheathed Cable, NonShielded Type.

Component Parts	*Specification Requirements*
Size of Conductors and Shipping Lengths	As specified in the order
Material of Conductor: Soft annealed copper, bare	ASTM B 3
Stranding: Compact Sector	AEIC Specifications—Solid Type
Insulation and Thickness	AEIC Specifications—Solid Type
Belt and Thickness	AEIC Specifications—Solid Type
Lead Sheath and Thickness	AEIC Specifications—Solid Type

Specification No. 574

Specification for Triplex No. 4 AWG to 500,000 CM, Paper Insulated, 11001–12000 Volt, (Grounded Neutral) Lead Sheathed Cable, Shielded Type.

Component Parts	*Specification Requirements*
Size of Conductors and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, bare	ASTM B 3
Stranding:	
Compact Sector	AEIC Specifications—Solid Type
Insulation and Thickness	AEIC Specifications—Solid Type
Shielding	AEIC Specifications—Solid Type
Lead Sheath and Thickness	AEIC Specifications—Solid Type

Specification No. 575.2

Specification for Single Conductor No. 18 AWG to 400,000 CM, Clean Stripping, Rubber Insulated, 0–300 Volt, 0–600 Volt Braided Cable for Train Lighting and Air Conditioning Service.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 8, Class C
Insulation:	
Heat Resisting Natural Rubber, or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation:	
No. 18 and No. 16 AWG	0-300 Volt, 2/64 inch, tolerance IPCEA-NEMA R
Other Sizes	0-600 Volt, IPCEA-NEMA R
Protection Over Insulation:	
No. 18 AWG and No. 16 AWG	None
Other Sizes	IPCEA-NEMA R, Tape or Braid
Braid Covering:	
No. 18 AWG and No. 16 AWG	Glazed cotton
Other Sizes	ASA C8.12 (Standard)
Saturant and Finish	IPCEA-NEMA R, Part 4, Indoor and Conduit Installations

Specification No. 577.2

Specification for Single Conductor No. 16 AWG to No. 10 AWG, 0–300 Volt, Rubber Insulated, Clean Stripping, Neoprene Jacketed Locomotive and Car Equipment Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Number of Concentric Strands:	
Nominal Size No. 16 AWG	19 of 0.0117″
Nominal Size No. 14 AWG	19 of No. 27 AWG
Nominal Size No. 12 AWG	19 of No. 25 AWG
Nominal Size No. 10 AWG	37 of No. 26 AWG
Insulation (Clean Stripping):	
Heat Resisting Natural Rubber	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation:	
No. 16 AWG to No. 12 AWG, Incl.	2/64 inch, tolerance IPCEA-NEMA R
No. 10 AWG	3/64 inch, tolerance IPCEA-NEMA R
Neoprene Jacket	IPCEA-NEMA R, Part 4
Thickness of Neoprene Jacket	.015″ Nominal
Overall Diameter	In accordance with Paragraph 2
Shipping Lengths and Packing	In accordance with Paragraph 3

1. Neoprene Jacket

A suitable lubricant shall be applied to facilitate pulling into conduit.

2. Overall Diameter

The overall diameter of the finished cable shall not exceed the following limits:

Nominal Size AWG	Outside Diameter
16	.171 Inch
14	.185 Inch
12	.195 Inch
10	.250 Inch

3. Shipping Lengths and Packing

The wire shall be delivered in coils of approximately 500 feet. Twenty per cent of the coils will be accepted if 200 feet or over. No coil shall be less than 200 feet in length, except when a coil submitted for inspection and testing has been cut to secure a sample for testing.

Both ends of every coil shall be accessible. The inside diameter of the coil shall be not less than nine inches. Every coil shall be securely bound with strong tape in at least four separate places and shall then be wrapped in burlap or strong paper so as to avoid mechanical injury during transportation,

Each coil shall have two strong tags, securely fastened, one to the inside, the other to the outside of the coil. The tags shall be plainly and indelibly marked to show the Manufacturer's name, railroad's order and requisition numbers, the gauge of the conductor, the number of strands, heat resisting type insulation, and the number of this specification 577.2.

Specification No. 579.1

Specification for Single Conductor No. 8 AWG to 300,000 CM, Extra Flexible, Portable Arc Welding Cable.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor: Soft annealed copper, bare	ASTM B 3
Stranding	ASTM B 172, Class M
Separator	IPCEA-NEMA R, Part 7
Neoprene Jacket	IPCEA-NEMA R, Heavy Duty
Overall Diameter	IPCEA-NEMA R, Part 7
Packing and Shipping	In accordance with Paragraph 2

1. Scope

This specification covers portable electrode holder or trailing cables.

2. Packing and Shipping

Both ends of every coil or reel shall be accessible. The inside diameter of the coil shall be not less than ten inches. Every coil shall be securely bound with strong tape in at least four separate places and shall then be wrapped in burlap or strong paper so as to avoid mechanical injury during transportation.

Each coil or reel shall have two strong tags securely fastened, one to the inside, the other to the outside of the coil or reel. The tags shall be plainly and indelibly marked to show the Manufacturer's name, the gauge of the conductor, the number of strands, the overall diameter, the number of this specification (579.1) and the order and requisition numbers.

Specification No. 580.2

Specification for Single Conductor No. 4 AWG to No. 4/0 AWG, Cable for Battery Connectors.

Table No. I

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	In accordance with Table No. II, See Paragraph 2
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469 See Paragraph 1
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679, See Paragraph 1
Thickness of Insulation	In accordance with Table No. II
Neoprene Jacket	IPCEA-NEMA R, Heavy Duty
Dimensions and Flexibility	In accordance with Table No. II, See Paragraph 4

Table No. II

Approx. Size AWG	*Conductor*				*Thick. of Insul. Inches*	*Overall Diameter, Inches*		
	Stranding							
	Kind	*Strands in Rope*	*Wires in Strand*	*Size of Each Wire AWG*		*Max.*	*Nom.*	*Min.*
4	Rope	19	7	#25	0.074	0.437	0.425	0.413
2	Rope	19	7	#23	0.078	0.525	0.510	0.495
0	Rope	61	7	#26	0.085	0.627	0.610	0.593
00	Rope	61	7	#25	0.100	0.718	0.700	0.682
000	Rope	61	7	#24	0.105	0.800	0.780	0.760
0000	Rope	61	7	#23	0.105	0.875	0.850	0.825

1. Insulation

The cable will be used in locations where sulphuric acid is present. The insulation shall be Heat Resisting Natural Rubber Compound, ASTM D 469, or Heat and Moisture Resisting Synthetic Rubber Compound, ASTM D 1679, protected by a jacket of compound in accordance with IPCEA–NEMA R, Part 4, Heavy Duty or complete insulation with compound in accordance with IPCEA–NEMA R, Part 4, Heavy Duty.

2. Stranding

An alternate stranding using the same number of wires to provide the exact size ordered will be acceptable under this specification.

3. Protective Coverings and Thickness

Neoprene jacket IPCEA–NEMA R bonded to insulation. A reinforcement of heavy cotton or seine twine may be applied between the insulation and sheath. The reinforcement shall be applied in the form of an open braid or two serves applied with opposite direction of lay. The openings in the reinforcement shall be large enough to allow the bonding together of the insulation and sheath.

4. Dimensions and Flexibility

The finished cable shall be uniform in diameter throughout its length and the overall dimension shall not exceed the values given in Table No. II of this specification.

Specification No. 581.3

Specification for Single Conductor, Clean Stripping Rubber Insulated, 0–600 Volt, Neoprene Jacketed Cable for Locomotive and Car Equipment.

Table No. I

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33 See Paragraph 3
Soft annealed copper, coated	ASTM B 189 See Paragraph 3
Stranding	In accordance with Table No. II, See Paragraph 2
Insulation (Clean Stripping):	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	In accordance with Table No. II
Tolerance	IPCEA-NEMA R
Separator	See Paragraph 4
Protective Coverings and Thickness	See Paragraph 5
Dimensions and Flexibility	See Paragraph 6
Finish	See Paragraph 7

1. Scope

This specification describes single conductor heat resisting rubber insulated, clean stripping, extra flexible, neoprene jacketed cable for use in locomotive and car equipment.

2. Stranding.

Uni-lay construction may be used if specified.

3. Conductors.

Conductor diameters shall not exceed the values given in Table No. II of this specification.

4. Separator.

A paper or other suitable separator shall be applied on sizes 36,700 CM and larger. Where insulation is applied by the strip process method, no paper separator is necessary.

Table No. II

Approx. Area (CM)	*Approx. Size AWG*	*No. and Size Each Wire in Strand*	*Type of Stranding*	*Conductor Diameter (Inches)*	*Insulation Thickness 64th Inch*	*Jacket Thickness 64th Inch*	*Maximum Cable Dia. (Inches)*
2601	16	19/.0117″	Conc.	.060	3	1	.20
3831	14	19/#27	Conc.	.070	3	1	.22
6088	12	19/#25	Conc.	.090	3	1	.23
10910	10	27/#24	Bunch	.123	3	1	.27
14950	8	37/#24	Conc.	.140	3	1	.31
24640	6	61/#24	Conc.	.180	4	2	.39
36760	5	91/#24	Rope	.220	4	2	.44
42420	4	105/#24	Rope	.240	4	2	.46
50500	3	125/#24	Rope	.260	4	2	.49
60600	2	150/#24	Rope	.325	4	2	.53
90900	1	225/#24	Rope	.390	5	3	.68
111100	1/0	275/#24	Rope	.420	5	3	.72
131300	2/0	325/#24	Rope	.460	5	3	.77
181800	3/0	450/#24	Rope	.565	5	3	.85
222200	4/0	550/#24	Rope	.590	5	3	.91
262600		650/#24	Rope	.660	6	3	1.01
313100		775/#24	Rope	.740	6	3	1.07
373700		925/#24	Rope	.790	6	3	1.16
444400		1100/#24	Rope	.870	6	3	1.24
535300		1325/#24	Rope	.970	7	4	1.36
646400		1600/#24	Rope	1.060	7	4	1.47
777700		1925/#24	Rope	1.120	7	4	1.57
929200		2300/#24	Rope	1.230	7	4	1.67
1111000		2750/#24	Rope	1.370	8	4	1.85

Note: At the option of the purchaser, the manufacturer's standard type of stranding will be acceptable providing that the conductor diameter does not exceed the values shown. The total number of strands shall be as specified, plus or minus one percent, except 150/#24 which may vary by minus two percent, providing that the conductor diameter does not exceed the values shown.

5. Protective Coverings and Thickness

Neoprene jacket, IPCEA–NEMA R bonded to insulation. Thickness of neoprene jacket in accordance with Table No. II of this specification.

6. Dimensions and Flexibility.

The finished cable shall be uniform in diameter throughout its length and the overall dimension shall not exceed the values given in Table No. II of this specification.

7. Finish

A suitable lubricant shall be applied to facilitate pulling into conduit.

Specification No. 582.2

Specification for Train Line Control Cable for Multiple Unit Cars and Electric Locomotives, 0–600 Volt, Clean Stripping, Rubber Insulated, Braided.

Table No. I

Component Parts	*Specification Requirements*
Number of Conductors	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	19 Wires Concentric
Size of Each Strand	No. 25 AWG
Insulation (Clean Stripping):	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	3/64 inch, Tolerance IPCEA-NEMA R
Braid Over Insulation and Order of Lay-Up	In accordance with Table No. II and Paragraph 1
Assembly	In accordance with Paragraph 2
Tape Over Assembly	One varnished cloth in accordance with Paragraph 3
Braid	IPCEA-NEMA R, Class C
Saturant and Finish	IPCEA-NEMA R, Indoor and Conduit Installation
Maximum Overall Diameter	In accordance with Table No. II and Paragraph 4
Shipping Lengths	1000 ft. See Paragraph 5

Table No. II

Items	*Train Line Control Cable for Multiple Unit Cars and Electric Locomotives*				
Number of Conductors	20	16	10	7	4
Maximum Overall Diameter	1.15″	1.05″	0.88″	0.75″	0.61″
Colors of Braids on Separately Insulated Conductors	Conductors to be without braid except one braided Red in first layer and one braided Black in second layer	Conductors to be without braid except one braided Red in first layer and one braided Black in second layer	Conductors to be without braid except one braided in first layer	White (Core) Green Black Yellow Red Green and White Red and Black	White Green Black Yellow

1. Braiding and Order of Lay-Up

The colors of the braids and the order of lay-up shall be in accordance with Table No. II.

2. Assembly

Four conductor cables shall be stranded by laying four conductors in a helix around a paraffined jute center.

Seven conductor cables shall be stranded by laying six conductors in a helix around a central conductor.

Ten conductor cables shall be stranded by laying nine conductors in a helix around a central conductor built up to the necessary diameter with paraffined jute.

Sixteen conductor cables shall be stranded by laying five conductors in a right handed helix around a paraffined jute center and eleven conductors in a left handed helix around the core so formed.

Twenty conductor cables shall be stranded by laying seven conductors in a right handed helix around a paraffined jute center and thirteen conductors in a left handed helix over the core so formed.

3. Varnished Cloth Tape

The varnished cloth tape shall be applied helically with turns overlapping at least one-third its width.

4. Dimensions and Flexibility

The finished cable shall be uniform in diameter throughout its length and the overall dimensions shall not exceed the values given in Table No. II.

5. Shipping Lengths

The cable covered by one order shall be shipped in one piece per kind per reel, if less than the length shown in Table No. I, otherwise it shall be shipped in pieces of approximately this length. The length supplied shall not differ from that ordered by more than three feet.

Specification No. 583.2

Specification for Control Jumper Cable for Multiple Unit Cars and Electric Locomotives, 0–600 Volt, Rubber Insulated and Neoprene Jacketed.

Table No. I

Component Parts	*Specification Requirements*
Number of Conductors	As specified in the order
Material of Conductor: Soft annealed copper, coated	ASTM B 189
Stranding	19 Wire Concentric
Size of Each Strand	No. 25 AWG
Separator	In accordance with Paragraph 1
Insulation: Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation	3/64 inch, Tolerance IPCEA-NEMA R
Braid Over Insulation and Order of Lay-Up	In accordance with Table No. II, and Paragraph 2
Assembly	In accordance with Paragraph 3
Tapes Over Assembly	Dry paper and cable tape, in accordance with Paragraph 4
Neoprene Jacket	IPCEA-NEMA R, Part 4, Heavy Duty
Thickness of Sheath	In accordance with Paragraph 5
Overall Diameter	In accordance with Table No. II and Paragraph 6
Shipping Lengths	1000 ft. unless otherwise specified in the order

Table No. II

Items	*Control Jumper Cable for Multiple Unit Cars and Electric Locomotives*			
Number of separately insulated braided conductors	20	16	7	4
Paper tape over assembly	1	1	1	1
Cable tape over core	1	1	1	1
Jacket	1	1	1	1
Overall Diameter:				
Maximum	1.56″	1.36″	0.96″	0.83″
Minimum	1.52″	1.32″	0.92″	0.79″

1. Separator

A paper separator shall be applied between the conductor and insulation.

2. Braiding and Order of Lay-Up

The braid on the individual conductors shall be applied after vulcanization and their color shall be in accordance with Table No. III. The braided conductors shall be laid up in the order indicated.

Table No. III

16 and 20 Conductor Cable	*7 Conductor Cable*	*4 Conductor Cable*
All white except one red in the first layer and one black in the second layer	White Green Black Yellow Red Green and White Red and Black	White Green Black Yellow

3. Assembly

The center of the control cable shall consist of a rope or fibrous material saturated with a moisture resisting compound.

The first layer of conductors shall be helically wound around the rope with a short lay and in a direction opposite to the direction of lay of the rope.

(a) The four conductor cable shall be stranded by laying the four conductors around a rope just large enough to strand the four conductors around it without deformation.

(b) The seven conductor cable shall be stranded by laying the seven conductors around a rope approximately 9/32 inch in diameter.

(c) The sixteen conductor cable shall be stranded by laying five conductors around a rope approximately 5/32 inch in diameter and eleven conductors in a helix in the reverse direction over the core so formed.

(d) The twenty conductor cable shall be stranded by laying seven conductors in a helix around a rope approximately 9/32 inch in diameter and thirteen conductors in a helix in the reverse direction over the core so formed.

4. Paper and Cable Tape

Over the assembly shall be wound a dry high grade Manila paper tape not more than seven or less than four mils thick which shall be applied helically overlapping at least one-third its width.

Over the paper tape shall be wound cable tape ten mils in thickness overlapping one-quarter of an inch.

5. Thickness of Jacket

The neoprene jacket shall have an average thickness of not less than 6/64 inch for the four conductor cables, 5/64 inch for the seven conductor cables, 10/64 inch for the twenty conductor cables and 7/64 inch for all others, and shall be applied concentrically about the assembled conductors. The minimum thickness shall be not less than 90 percent of the specified thickness.

6. Overall Diameter

The finished cable shall be uniform in diameter throughout its length and the overall diameter shall not exceed the limits given in Table No. II.

7. Shipping Lengths

The cable covered by one order shall be shipped in one piece per kind per reel, if less than the length shown in Table No. I, otherwise it shall be shipped in pieces of approximately this length. The length supplied shall not differ from that ordered by more than three feet.

Specification No. 584.2

Specification for Single Conductor No. 2/0 AWG, No. 4/0 AWG and 500,000 CM Bus Line Jumpers for Multiple Unit Cars and Electric Locomotives, 0–600 Volt, Rubber Insulated and Neoprene Jacketed.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
Soft annealed copper, tinned, or	ASTM B 33
Soft annealed copper, coated	ASTM B 189
Stranding	ASTM B 172, Class I
Insulation:	
Heat Resisting Natural Rubber or	ASTM D 469
Heat and Moisture Resisting Synthetic Rubber	ASTM D 1679
Thickness of Insulation:	
No. 2/0 AWG and No. 4/0 AWG	5/64 inch, Tolerance IPCEA-NEMA R
500,000 CM	6/64 inch, Tolerance, IPCEA-NEMA R
Reinforcement between Insulation and Jacket	In accordance with Paragraph 1
Neoprene Jacket	IPCEA-NEMA R, Heavy Duty
Thickness of Jacket:	
No. 2/0 AWG and No. 4/0 AWG	5/64 Inch (Min. Avg.)
500,000 CM	6/64 Inch (Min. Avg.)
Overall Diameter	In accordance with Paragraph 2
Shipping Lengths	1000 feet, unless otherwise specified in the order

1. Reinforcement Between Layers

Either seine twine, cotton cord or cabled cotton shall be applied between insulation and jacket as an open braid or open spiral winding. The winding shall consist of not less than five strands.

2. Dimensions and Flexibility

The finished cable shall be uniform in diameter throughout its length and the overall diameter shall not exceed 0.86, 1.00 and 1.50 inch for sizes No. 2/0 AWG, No. 4/0 AWG and 500,000 CM, respectively. The cable shall be capable of being bent to a radius of six times its diameter without injury.

Specification No. 585

Specification for Flexible Rope Stranded Copper Cable for Third-Rail Shoe Shunts and Leads.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Material of Conductor:	
No. 1/0 AWG and No. 3/0 AWG	ASTM B 3
500,000 CM	ASTM B 33
Stranding	ASTM B 172, Class M Modified
Lay of Strand	In accordance with Paragraph 1
Maximum Overall Diameter:	
No. 1/0 AWG	7/16 Inch Approximately
No. 3/0 AWG	9/16 Inch Approximately
500,000 CM	15/16 Inch Approximately

1. Lay of Strand

The lay of the stranding of the No. 1/0 AWG and No. 3/0 AWG cable shall not exceed five (5) times the diameter of the finished strand or cable.

Specification No. 586.1

Specification for Duplex, No. 18 AWG to No. 12 AWG, 0–300 Volt, Asbestos and Varnished Cloth Insulated Locomotive Cab Cord.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Completed Wire and Cable: Strand: ASTM B 8, Class B	In accordance with ASA C8.36 Type AVPD, Designation No. 28

Specification No. 587.1

Specification for Single Conductor No. 18 AWG to 2,000,000 CM, Varnished Cloth and Asbestos Insulated, 0–600 Volt, Asbestos Braided Cable for Use in Excessively Hot But Dry Locations

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Completed Wire and Cable:	
Strand: ASTM B 8, Class B	In accordance with ASA C8.36 Type AVA, Designation No. 1

Specification No. 588.1

Specification for Single Conductor, No. 14 AWG to No. 6 AWG, Varnished Cloth and Asbestos Insulated, 0–600 Volt, Braided Switchboard Wire.

Component Parts	*Specification Requirements*
Size of Conductor and Shipping Lengths	As specified in the order
Completed Wire and Cable:	
Solid Conductor	In accordance with ASA C8.36 Type AVB, Designation No. 6

Page 5–1–2, Electrical Manual

Specification for Polyvinyl Chloride Tape

i. Accelerated aging factor—(Percent—maximum) 150 150
Change the 150 to 200 in each instance.

Report on Assignment 11

Electric Heating

Collaborating with Committee 6, and Mechanical Division, AAR

R. A. Mather (chairman, subcommittee), G. N. Burwell, H. C. Cross, L. B. Curtis.

Your committee submits the following report as information. It summarizes present data on railway applications of electric heating and should provide a guide for future committee activities.

Switch Heating

It is felt that this subject is adequately covered in the current Electrical Manual. However, any new developments will be studied.

Car Thawing—Melting

Currently about 40 electrical car-thawing installations are in operation in the United States. They are owned and operated principally by railroads, mines and public utilities. Mostly used in conjunction with thawing sheds, the devices are also operable without sheds. Power consumed ranges from 2.8 to 5 kwh per ton, depending on whether the cars are to be unloaded by invertion or by bottom dumping, and the grade and history of the contents. Initial costs run $2500 to $3500 per car per hour of thawing capacity, exclusive of electrical service for the facility.

Both quartz-enclosed and metal tubular heating elements in reflective housings are in use for applying heat to coal cars, ore cars and other types of lading, and, with modification, to tank cars containing semisolids, such as lard, molasses, etc. Even empty cars frequently require deicing and snow removal.

Car Finishing and Refinishing

Freight car finishing and refinishing is frequently accelerated or accomplished by the use of electric radiant heat. This method is used either for indexing or continuous handling. In cases of low production, moving equipment has been used. Power consumption varies from 175 to 500 kwh per car, depending partly on the physical size of the installation and its construction. Initial costs range from $5000 per car per hour of drying capacity, not including electric service to the facilities.

Rail Heating

Heating continuous welded rail before laying to control expansion is a relatively new development which would appear to be a potential radiant heating application.

Weed Killing

Some exploratory work has been done toward developing a radiant weed killer for right-of-way use. A travelling unit has been proposed, to be energized from a diesel power unit. Further thought will be given to this possibility.

Track Bed Thawing

Where it is desirable to thaw out frozen trackage in the winter, applying the necessary heat to the track presents a problem. Preliminary investigation indicates that, with electric radiant heat, frozen ground can be thawed at a rate of about 1 in of depth per minute, at 2 kw per sq ft. Stated another way, a 1000-kw unit could thaw about 8 in of depth while moving at a rate of 4 ft per min.

Journal Heating

To improve the rollability of cars in winter humping operations, it is proposed to further explore journal heating by electric radiant heat.

People Heating

Much material is available on this subject, and the committee will attempt to summarize field test data and draw some general conclusions.

Snow Melting

Radiant heat is being used for removing snow from platforms, switch areas and other yard areas. Some comparisons will be made with other methods.

Miscellaneous

The committee will attempt to keep abreast of activities in electric bin hopper heating, wheel shrink fitting, gear heating, and other shop applications of electric heat and will discuss them in future reports.

The committee solicits guidance from members with specific interests in these or related fields.

Report on Assignment 13

Railway Electrification

Collaborating with Mechanical Division, AAR

B. C. Hallowell (chairman, subcommittee), R. J. Berti, L. W. Birch, W. F. Bowers, H. F. Brown, R. Burn, F. J. Corporon, L. B. Curtis, A. C. Held, G. B. Hauser, D. R. MacLeod, C. F. Mulrenan, F. B. McConnel, E. B. Shew, E. L. Tennyson.

Your committee reports as information on the general subject of railway electrification. Of the six assignments to our subcommittee, only one is reported on this year. The report follows.

Report on Assignment 13–D

Developments in the Field of Electrification (Domestic and Foreign)

L. W. Birch, *Chairman*

UNITED STATES DEVELOPMENTS

Recent electrification developments in the United States actually reflect experiments and research rather than any appreciable amount of commercial development. However, the Pennsylvania Railroad is now operating six 4400-hp electric locomotives equipped with silicon rectifiers on its 11-kv, 25-cycle electrified zone. The Long Island Railroad recently installed two 3000-kw silicon rectifier stations to serve its commuter lines (see Fig. 1). The more recent of these Long Island silicon rectifiers was placed in service at Merrick, N. Y., March 6, 1964, for supply to the road's 650-v, d-c third-rail system. This is the first such unit built in this country for outdoor service. The unit is very compact, requiring a plot of ground only 30 by 65 ft in area.

All the components of the silicon rectifier—d-c feeder breakers, ventilation facilities for cooling the silicon diodes, surge protectors, interphase transformer, protective relays and controls, including supervisory control, storage batteries and battery charger—are contained in a sectional metal housing.

The main power transformer and the metal housing for the rectifier and d-c switching gear, were installed on a concrete foundation, 29 ft by 12 ft 3 in, with the required cable ducts for the outgoing d-c feeder cables. The steel reinforcing rods of the foundation were utilized as a ground mesh, which, connected to the grounding system, provides maximum protection against lightning surges.

The metal housing was shipped by the manufacturer in five sections and assembled in the field. The main power transformer has a throat connection on its secondary side bolted to the rectifier housing where the low-voltage phases are also connected to the silicon rectifier assembly.

An aluminum structure was erected adjacent to the main power transformer to accommodate the utility company's metering facilities, disconnect switches and high-voltage lightning arresters. In the area of the high-tension structure an oil circuit breaker was installed on a separate foundation with connections to the utility and to the rectifier transformer.

Substations of the type installed at Merrick have a number of advantages for electric traction service. The ones that should be considered in making traction system studies are:

1. The outdoor type of metal-clad housing requires less land than a building with an indoor rectifier unit.
2. Tax assessments would be lower for an outdoor unit compared to a building with an indoor unit.
3. The outdoor unit does not require as many conduit runs and as much wiring, since the unit has wire troughs built in the assembly to accommodate the control circuits.
4. The outdoor unit is factory wired, which reduces installation labor costs. It is necessary only to connect jumpers at points where the sectional splits are

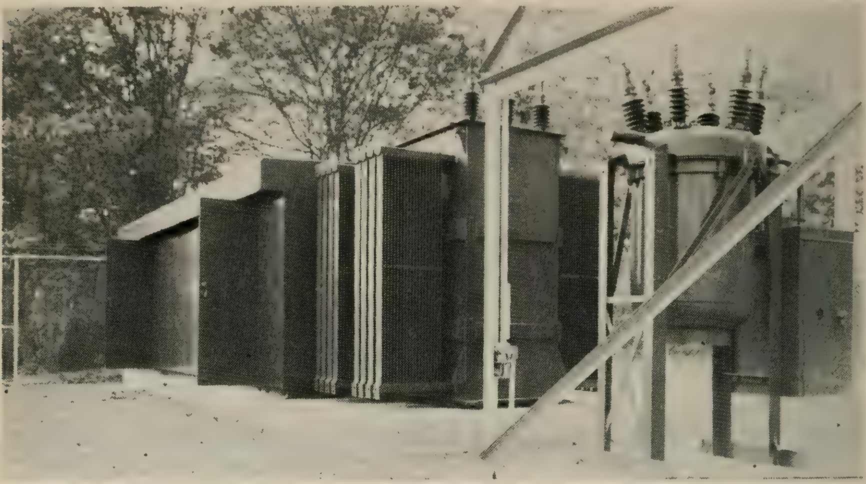


Fig. 1.

located in the housing. An 80 percent labor saving for the assembly of the substation equipment is possible over the indoor type.

5. The reduction in the size of the housing permits reducing the capacity of the heaters needed to control and protect against condensation for operation during lightly loaded periods. While very compact, the outdoor unit provides sufficient space for maintenance.

Progress is being made by various traction systems in replacing old d-c rotary converters, and the trend in other industries is toward the use of the silicon rectifier rather than the ignitron and other types of mercury-arc rectifiers.

To date the following installations of silicon rectifiers are in service, or on order:

Now in Service

Three 2500-kw units, Chicago Transit Authority
One 3000-kw unit, New York Transit Authority
Three 1500-kw units, Niagara Junction Railroad
One 3000-kw unit, Long Island Railroad

Under Construction

Four 3000-kw units, New York Transit Authority
One 3000-kw unit, Grand Avenue Substation, Long Island Railroad
Two 3000-kw units, Substation 1, City of Long Island

New Third-Rail Contact Shoe

The Long Island has also developed a new third-rail contact shoe (see Fig. 2). The reason for this development and the proposed abandonment of the old shoe may be attributed to its weaknesses: It weighed too much; the springs that held it in a down position were too weak; the arms that held it were inadequate and often cracked

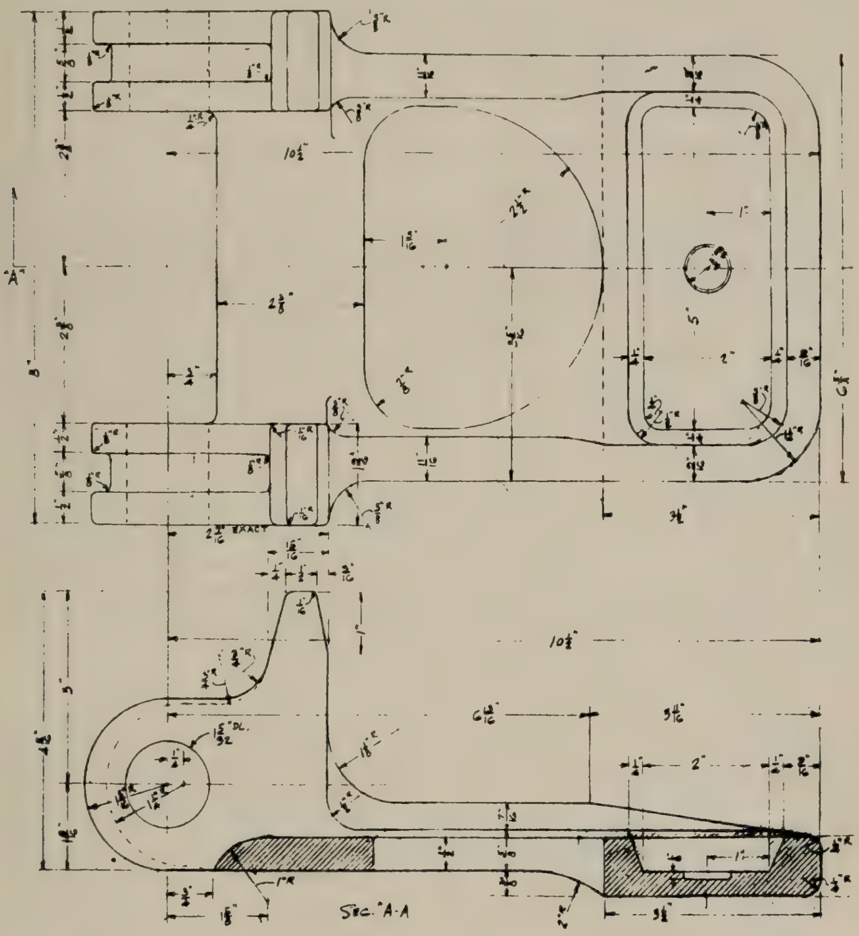


Fig. 2.

and broke; the stop joints at the top of the shoe were poorly designed, and usually only one of the two made contact at a stop. Because of these weaknesses, third-rail misalignment caused breakage, and the third-rail configuration at crossovers caused vibration in the shoes and produced additional breakage.

The new design was made on the basis that the shoe could be easily broken if necessary to isolate a car but should not break in normal service. The breaking location is well back into the heel to prevent a stub from protruding thus eliminating the possibility of pushing over the third rail. It is also lighter in weight.

The new shoe weighs 16 lb (3 less than the former shoe), costs 50 cents less than the old shoe and is made of grey cast iron, the same as the old shoe. The shoe is completely different in appearance; it has a flat paddle-type contact arm with no sharp edges. The old shoes had sharp edges for ice scraping purposes. The electrical contact area is slightly greater than on the old shoe.

To date the success of the new shoe has been rather phenomenal, shoe breakage has been reduced to almost zero.

Recent Rapid Transit or Commuter Railroad Developments

San Francisco

San Francisco's 75-mile, double-track, billion-dollar installation, which will include both surface and underground trackage, will be in operation in 1967 and will require 450 rapid-transit cars. At the present time preparations are being made for extensive experiments on a section of track located on the old right-of-way of the Sacramento & Northern Railway in the East Bay area. Tests will be made of track designs, distribution systems, collection of current, voltages, motors and many other items.

Housing and Home Finance Agency grant of $1,333,333 was announced to assist in financing extensive field tests of the relative merits of alternating current and direct current for vehicle propulsion.

Philadelphia

An extension to the Broad Street subway has been proposed, in which 6.5 miles would run northwest along Roosevelt Blvd. to Rhawn St. A 1.4-mile segment would extend directly south to Patterson Ave. Voters will pass on a $90 million bond issue in November. This subway operates with 600 v, d-c.

The Delaware River Port Authority has provided money for the construction of a 14.5-mile third-rail 600-v, d-c facility between Philadelphia and Kirkwood, N. J. A total of 84 new rapid-transit cars will be necessary.

Toronto

The Toronto Transit Commission placed in operation during 1964 the University Extension, two miles long, and is now constructing the Bloor Danforth east-west eight-mile section which will be completed in another three years. A total of 164 new cars has been ordered for this 600-v, d-c third-rail system. The complete project will be carried out under an accelerated construction schedule made possible by a $29,482,000 Federal loan.

Cleveland

Cleveland expects to start construction on the Airport Extension, which will be a little more than four miles long. It is to have a 600-v d-c catenary overhead system.

Montreal

Montreal's rubber-tired rapid-transit cars will be in operation in another two years. They will be propelled by 600-v d-c motors. The energy will be picked up from a third-rail system. A total of 369 cars will be necessary for the initial operation.

Chicago

Chicago has just purchased 180 new high-speed cars. About a year ago the city placed in operation a two-mile-long elevated section of line at the western extremity of the Lake Street elevated. Some of the new cars will be used on the Lake Street line. In order to elevate the Lake Street line it was necessary to use a portion of the North Western Railway grade which is approximately at elevated structure height.

The latest development at Chicago involved the abandoned Chicago, North Shore & Milwaukee Railroad between Dempster Street and Howard Street. This five-mile section built with a 600-v, d-c catenary system, has been reconditioned and is now handling three times the traffic originally planned.

An H.H.F.A. grant of $349,217 was provided to determine the effectiveness and economic feasibility of linking a fast-growing, medium-density suburban area with the central city by means of a high-speed rapid transit system.

Pennsylvania Railroad

Since the last report on the Pennsylvania Railroad's commuter service, 17 new MU (multiple-unit) cars have been added to the Philadelphia fleet (see Fig. 3). At the present time the Pennsylvania is applying for 20 additional cars. These new cars will be owned by the Passenger Service Improvement Corporation and will be leased to the Pennsylvania–Reading Seashore Lines.

Reading Company

The 11-kv Reading commuter service using catenary overhead recently acquired 38 MU cars for commuter service.

Long Island Railroad

The Long Island commuter system operating electric trains in the western section of Long Island placed in operation 30 MU cars in time for the opening of the New York World's Fair. The electrification is 650 v, d-c, third rail.

Pittsburgh

The Port Authority of Allegheny County was granted a $759,000 H.H.F.A. Supplement to the previous grant of $2,113,000 made in June 1963, to assist in financing the construction and testing of a new-concept rapid-transit system to serve medium-density urban areas.

This system involves the use of light rubber-tired rapid-transit cars fully automated and electrically powered with a 500-v 3-phase a-c elevated system and is designed for cities in the 500,000 to 2,000,0000 population bracket.

Seattle

The $4.5 million Alweg 1.2-mile monorail built in 1962 for direct service to the World's Fair has been operated successfully by a nonprofit organization. The city granted the street-use permit necessary for continued operation.

Tokyo

The 8.25-mile Alweg Line, longest in monorail history, was inaugurated in time for the Olympic Games. Linking the city with the airport, it was built at a cost of $54 million.

Automatic Train Operation

During the past year there has been considerable development and research relative to the automatic operation of trains—railroad, mine and rapid transit. The Virginia Electric and Power Company has installed an automatic coal-handling locomotive capable of handling 80 loaded cars to a coal dumper. Automatic control of a mine train on the Carol Lake Project in Canada is about completed. Satisfactory tests and even commercial operation were made during the mining season of 1964. The San Francisco Bay Area Rapid Transit District will make use of considerable automatic operation on the new billion-dollar rapid transit project which extends from San Francisco into the East Bay.

It is interesting to note that rapid transit experiments are being made in London for the automatic control of trains.

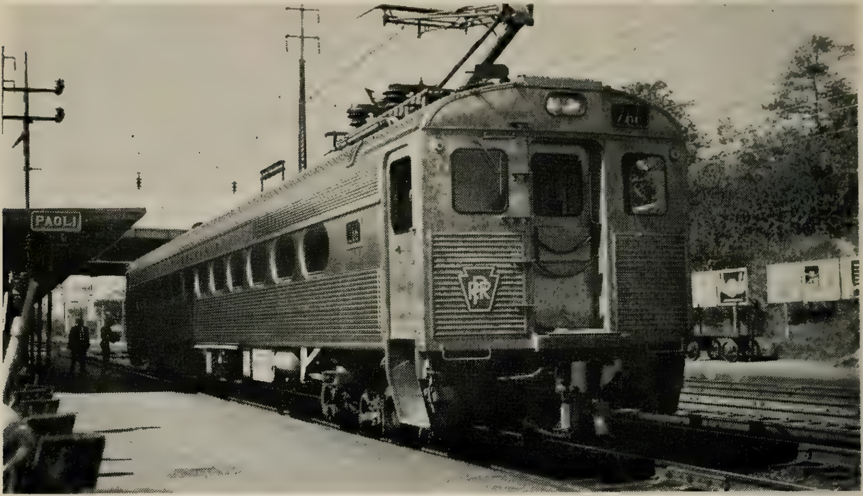


Fig. 3.

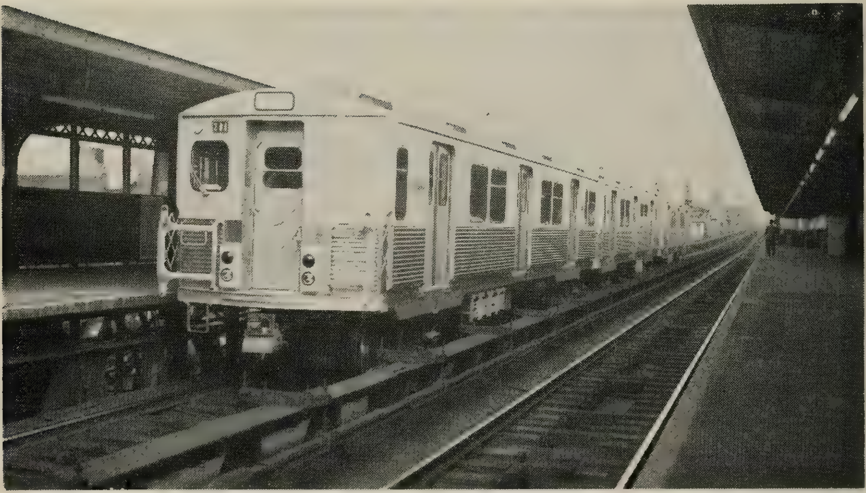


Fig. 4.

FOREIGN DEVELOPMENTS

Included in the foreign developments for 1964 is the approval by the Polish State Railways of basic plans for electrification of the coal road between Tarnowskie Goroy in Silesia to Gdynia. The first section of this line to be completed in 1965 is approximately 100 miles in length.

Austria has been receiving new locomotives aggregating a total of 40 for operation on its 15-kv, 16⅔-cycle system. These locomotives are rated at 4800 hp and 283 tons and have a maximum speed of 81 mph.

By the end of 1966 approximately 16 percent of the railway system of South Africa and Southwest Africa will be operated electrically. Total electrification will amount to 2119 route miles.

The Bas Congo au Katanga was the first railroad to place a continuity of orders for the modern type of 50-cycle, single-phase, 25-kv electric locomotives. The first order for 12 was placed in 1952 and the most recent order in 1964. Last year the silicon-rectifier locomotives for the 25-kv, 50-cycle line were also placed in service.

The new Tokaido Line built between Tokyo and Osaka has gone into service. This 320-mile catenary system is being operated with speeds providing a 3-hr run between the two cities. The line is modern in that 25-kv, 50-cycle supply is used for traction purposes.

Chile has ordered an additional eight commuter trains for operation on its 3000-v, d-c catenary system.

The French National Railways ordered in 1964 new locomotives which can be used on 4-current systems now employed by certain European rail lines. These locomotives, which will run on various voltages and even various frequencies, will eliminate the necessity for changing engines at the borders between European countries. They will operate on the Paris–Brussels–Amsterdam service.

Switzerland, during the past year, installed several new 15-kv, 16⅔-cycle locomotives of 5100 hp capacity with a maximum speed of 65 mph. Regeneration will be used on all steep grades.

A CONDENSATION OF THE LAST SEVEN YEARS OF AAR AND AREA REPORTS

The secretary of the American Railway Engineering Association has mailed printed copies of this report to all interested parties in the mechanical and electrical departments of the railroads of the United States and Canada.

LESSENING COST OF DISTRIBUTION SYSTEM

Our study on the lessening of distribution system costs has uncovered interesting information relative to weights and parts, also standardization and use of various metals. It is suggested that in addition to this report the reader review the paper by L. B. Curtis, senior member IEEE and formerly chairman of Subcommittee 13. The subject of his IEEE paper is "Standard Engineering for Standard Electrification."

There are two major reasons for the need to lighten the catenary system (which is really the distribution system for a 25-kv, commercial frequency electrification), namely, (1) to lessen its cost, and (2) to lessen the cost of the supporting structures.

While the desire to lighten the catenary system is a logical one from an economic viewpoint, the accomplishment is quite complex.

The size, and thus the weight, of the catenary system depends upon three major factors, each succeeding one affecting the one or ones ahead of it.

In the first place, the system must be capable of carrying the current load imposed upon it by the number and size or weight of the trains operating under it. Hence, the contact wire plus the messenger wire must have the necessary conductivity to carry the electric load without overheating, and at the same time avoid excessive voltage drop. It is possible to design a relatively light catenary system to meet these objectives, particularly at 25-kv, but a second factor will undoubtedly tend to increase this minimum weight.

In the second place, the catenary system must have the necessary strength to carry the physical loads imposed upon it, namely, its own weight, the weight of snow and ice in most areas in this country, and the wind loads. Generally, these loads will make a heavier system mandatory. However, there is a third problem that will affect the weight of the system, increasing the weight still further.

In the third place, the contact wire must have sufficient cross-section to give it as long a life as economically possible. As electrification will be used only in areas of heavy traffic, the number of pantograph passes will be large, with resultant accelerated wear. As labor costs to replace worn contact wire dominate the cost of change, the fewest number of changes is most desirable. Hence, the most logical contact wire to use is the so-called deep or Figure 9 Section.

The net result of these three conditions is to limit within a narrow range the weight of the catenary system. One hope for relief is in the use of lighter materials. But here again the designer is frustrated. Experience has shown that bronze contact wire has the best combination of conductivity, strength and wear. To date there is no other choice. The only other parts of the system are the messenger, hangers and clips, with the messenger adding the most weight. This wire could be made of aluminum alloy, aluminum conductor, steel reinforced or even stainless steel of relatively small diameter, if this material combined with the bronze contact wire would satisfy conductivity and voltage-drop requirements—which is doubtful. Hangers, and even clips could also be made of aluminum. Aluminum and bronze, however, are far apart in the galvanic series scale, and the electrolytic problem is still not satisfactorily solved.

Lower costs can be achieved, however, by making all the components of the catenary system standard for all railroads. Then greater quantity buying, and lessening the need for large quantities of each item to be kept on hand in the stores account will lessen the initial cost and also the maintenance cost.

Consideration of the supporting structures indicates many possibilities of reducing costs, with the 60-cycle, 25-kv system of electrification:

1. Elimination of transmission lines will greatly reduce the height of poles and the loads imposed upon them, thus decreasing the section of the pole.
2. Lowering the catenary height to 19 ft in place of the present standard of 22 ft will also contribute to size and cost reduction.
3. Standardizing on a one-track bracket pole to be used in all one- and two-track sections of any railroad, will through simplification of design and quantity of buying, reduce costs.
4. The combination of the above three items will make guys unnecessary except on heavy curves, thus eliminating a high cost item.

5. With lower contact wire height, it is possible to increase the spacing of structures, reduce the number per mile and reduce the mechanical loads.
6. Studies indicate that the structures can be worked at higher tensile strength than formerly thought possible, thus allowing a lighter section to be used.
7. Duplication of structure design can be avoided by giving the pole manufacturer the location and size of loads, and letting him prepare the detailed fabricating drawings, which he would do anyway.
8. Aluminum poles are beginning to compete in price with steel poles. Use of aluminum poles will lessen the cost of installation because of their relatively light weight, and reduce maintenance, since no painting would be required.
9. In large sections of railroads, off-track equipment can be used to erect the poles and catenary system, and later to maintain the catenary system—further reducing both sets of costs.
10. Lightening the structures as listed above will reduce the size and cost of foundations—even making precast foundations a distinct possibility. Furthermore, it is possible that with these reduced loads wood poles could be used, eliminating foundations entirely.

Summary

Overall standardization of the distribution system will reduce the cost of the catenary system in spite of the limitations noted above, and all the factors enumerated for the supporting structures will greatly reduce their cost. Thus, by coordinating the design and taking advantage of all the savings possible with the commercial frequency, 25-kv system, the lessening of the cost of the distribution system is not only a possibility but a distinct fact. The overall savings compared to present systems in use in this country will be surprisingly large.

MATERIALS AND METHODS FOR ELECTRIFICATION

The portion of Subcommittee 13's assignment dealing with overhead materials and methods for erection and maintenance includes not only fixed-property materials but off-track and on-track trucks for maintaining the catenary system without killing the electrical supply.

Aluminum Structures

Fixed-property structures which could be constructed wholly or partly of aluminum include those involved in the supporting system, transmission system, distribution system and substations.

Some of the characteristics of aluminum structures are:

1. They may be used in areas where advantage can be taken of the savings that accrue through reduced maintenance over the life of the structures and the light weight during installation.
2. The light weight of structural aluminum components eliminates the need for the heavy-duty lifting equipment required for galvanized steel structures, reducing erecting costs.
3. Power outage for paint maintenance of substations is a universal practice. Since they do not require painting, aluminum structures eliminate the power outage and service interruption.
4. Many utilities in their economic studies have justified the use of composite aluminum-steel towers wherein the upper part, cage and crossarms are alumi-

num. The lower part may be painted without a power outage. The upper part does not need paint.

5. Under average conditions of terrain and typical erecting techniques, self-supporting aluminum transmission towers can be expected to have an in-place cost about 30 percent greater than galvanized steel. Guyed aluminum towers and composite aluminum-steel self-supporting towers can be expected to have an in-place cost 20 percent greater than self-supporting galvanized steel towers. Specialized erecting techniques employed under ideal conditions may bring a more favorable in-place cost relationship for aluminum towers.
6. Metal structures are usually a small part of the cost of a complete substation, so the use of aluminum increases the first cost by only a small percent.
7. Definite aluminum specifications should be established, rather than using steel structures as a basis for alternate quotations. A number of utilities now have standard designs for aluminum substation structures.

New Materials, Processes, Components and Assemblies

The following material is excerpted from Paper 33A, "Developments in Overhead Equipment," presented at the British Railways Electrification Conference on Railway Electrification at Industrial Frequency, London, 1960.

New Materials

Although of relatively recent application to the catenary system it seems probable that few materials offer such scope for development as the resin-based materials of the phenolic, epoxide or polyester types. Included in this general category is a wide range of casting resins, adhesives and moulding compounds which can give good resistance to thermal shock, chemical stability, high mechanical strength and satisfactory electrical performance. They may be modified by the inclusion of inorganic fillers, the addition of internal reinforcement or the application of protective surface finishes to improve their electrical and mechanical characteristics.

Chief among the reinforcing materials now in use is glass fiber. Used in the manufacture of moulded components and in the production of laminates, tubes and rods, glass fiber can give reinforced products extremely good mechanical properties.

The electrical performance of resin-based materials is limited by their susceptibility to surface tracking under high electrical stress, and this is particularly apparent in the presence of dust or salt deposits when areas of high electrical stress develop even with low or medium voltage applications. Prolonged outdoor testing at stresses up to 5000 volts/inch has shown that the incorporation of hydrated alumina, silica, mica and other inorganic fillers yields a marked improvement in anti-tracking properties. Such additions however require careful control of the particle size of the filler employed, and where they are included at the expense of the glass content in glass-reinforced resins, a lower mechanical strength will result. For these reasons surface protection by other means is preferred. Sleeves of silicone rubber, P.T.F.E. (polytetrafluoroethylene) and ceramics have been successfully used with glass-fiber rod insulators and further studies made of protective varnishes and surface depositions of P.T.F.E. in suspension. Despite the high initial cost, P.T.F.E. offers many advantages, being chemically stable and possessing natural moisture and dirt repellency; in the form of sleeves, P.T.F.E. is flame and arc resistant and serves to protect the underlying glass-fiber insulation from tracking and the effects of weathering and local heating.

For other applications consideration is being given to the use of the high-strength alumina ceramics and devitrified glass. Although of high density and lower tensile strength than resin-bonded glass fiber, these materials possess extreme hardness and chemical stability with resistance to arcing, heat impact and weathering. The properties of the ceramics are capable of considerable modification during manufacture to meet specific requirements and seem well suited to their projected development as insulating and mechanical members of the catenary system.

New Processes

In the aircraft and other industries resin adhesives are widely used in place of welded, riveted and bolted connections. For galvanized steel work, where fitted bolts cannot be used, it has already been shown that resin filling of the clearance in the hole reduces the deflection of a structure.

For railway catenary systems the application of resin adhesives to porcelain/metal connections and to the termination of glass-fiber insulators has been studied. The adaptation of these materials to structural steel work also offers promising lines for exploration.

For the connection of smaller components and wires the technique of compression jointing is now highly developed and affords a reliable and simple method of attachment. Using hydraulic pressure, ferrules of steel, aluminum, copper, malleable cast iron and other metals may be compressed on to structural sections which include rods tubes, flat strip or stranded conductors. Similarly, the ends of tubular members may be compressed on to inserts or smaller section. This method is now used extensively to dispense with bolted connections and to simplify assembly. Compression joints are used to terminate glass fiber rod insulators, the length and size of the ferrule determining the strength of the joints which may be consistently reproduced.

New Components

Many thousands of insulators are required in the installation of an electrification system. Hitherto these have been usually of porcelain and have given satisfactory performance under widely different climatic and loading conditions. There remains, however, the obvious susceptibility of porcelain to damage from impact whether during or after erection. At overlap spans, neutral sections and section insulator locations the bulk and weight of porcelain insulators and end fittings impose limitations on the design of these arrangements for high-speed runing.

It is thus opportune that following an extended period of development, resin-bonded glass fiber should be adopted by the British Railways as one of the standard forms of insulation for future work. Possessing high impact and tensile strength, lightness and flexibility, glass fiber insulators will be used at those locations where these properties may be used to maximum advantage. The insulators will take the form of resin-bonded glass fiber rods of various diameters fully protected by P.T.F.E. sleeves and terminated by compression ferrules.

A new form of section insulator has been designed, weighing much less than the porcelain designs and completely symmetrical to preserve stability and give equal performance in either running direction. The design incorporates two P.T.F.E. covered glass-fiber insulating tension members and runners of toughened glass which are provided to protect the P.T.F.E. from abrasion or cutting by the pantograph.

The application of glass-fiber insulation to neutral sections is likely to have equally far-reaching effects. Here it is intended to use short lengths of insulation cut into the contact and catenary wires to replace the complicated and costly provision of four air-gap clearances at the standard carrier-wire high-speed neutral sections. The current used for four-section insulators for this purpose is not suited for running at the higher speeds where the additional weight and loss of flexibility become important. Ideally the insulation inserted in the contact wire should not introduce any irregularity likely to impair the quality of current collection. The use of glass-fiber insulation, with a ceramic or other covering to resist abrasion, should enable an advance to be made towards this objective.

New Assemblies

It is generally accepted that to obtain a high quality of current collection at speed over the ambient temperature range it is essential to prevent tension variations in the contact and catenary wires and to compensate for the thermal contraction and expansion. The most usual method of securing this objective is by terminating the wires using a system of pulleys and balance weights, and this arrangement is necessary at each anchor position. Apart from the expense of this system, difficulties arise under broken wire conditions, and several types of balance weight arrestor have been tried in different countries with varying degrees of success. In cooperation with other manufacturers, designs have been produced of a hydraulically tensioned conductor termination. This design suffers from none of the defects of the earlier balance weight arrangement. In principle, the conductors are tensioned by fluid pressure acting on a piston which moves in a cylinder of length equivalent to the maximum extension of the conductors due to temperature variation. It is simpler, very much cheaper, employs standard components, requires no arrestor device and tends to compensate for the friction drag at cantilever or roller supports.

Catenary Maintenance Equipment

The Live-Line Barehand Method

The electric utility industry first heard of the Live-Line Barehand Method late in 1960, but the principle upon which this new maintenance technique is based has been known since 1837. In that year Michael Faraday showed that a difference of potential cannot exist within a conductor. As a result of that principle, a human being may be energized at a high voltage without shock or discomfort if he is completely enclosed in a metal screen or "Faraday Cage" and is insulated from a ground or other conductors.

With the live-line method, the Faraday Cage is replaced by a metal-lined fiberglass bucket, and insulation from a ground is provided by the insulated arm of the aerial elbow.

As long as the man in the bucket is at the same potential as the conductor he is working on, and as long as he is completely insulated from a ground, no current can flow from conductor to man. He can work safely barehanded on the conductor—or on any metal fittings at the same potential as the conductor—without experiencing discomfort of any kind.

This new technique will lead to substantial and far-reaching revisions of long-standing maintenance procedures and practices throughout the industry. In another sense, however, acceptance of the new method is not at all remarkable. The many benefits are of such importance that it would be difficult to ignore them. The primary benefit is dollar savings, which may be expressed in more specific terms as follows:

1. *Man-hour Savings.* On hundreds of typical maintenance jobs, direct comparisons between the Live-Line Barehand Method and conventional "hot-stick" methods have shown man-hour savings in favor of the new method.

2. *Service Continuity.* Maintenance and repair jobs that formerly required removal of a line from service now can be completed while the line remains energized.

3. *Safety*. LLBM depends upon the safe use of equipment and trained employees. Many hazards are reduced or eliminated. Less pole climbing is involved and, therefore, fewer risks exist. Accidental contacts are less likely to occur. Bad-weather emergency work is made less hazardous with mechanized equipment. Fatigue, a primary cause of accidents, is also sharply reduced.
4. *Utilization of Older Employees*. Experienced linemen over 40 years old, and their employers are no longer penalized by the increasing difficulties encountered by older men in climbing and working on poles and structures. The skills of experienced older employees can be fully utilized for many more years than they ordinarily would expect.

These are but a few of the major benefits. Other benefits include those associated with efficiency and morale.

Figs. 5 and 6 illustrate typical commercially available "hot-line" work equipment.

The truck equipment includes four hydraulically operated jacks, two front and back, to provide a solid stabilizing platform for insulated elbows in 23 ft, 42 ft, 57 ft and 65 ft work heights in any elbow position. The insulated elbows are equipped with a specially designed test circuit to give true readings of upper-arm leakage currents when a microammeter is connected at the base of the elbow. This makes it possible to monitor the condition of the arm insulation at regular intervals during field use, thereby allowing workmen to detect deterioration in the basic insulation level before it becomes hazardous.

The twin fiber-glass buckets, with electrically interconnected shielding, are rated at 300 lb capacity. Manual swiveling mechanisms allow each crewman to independently swivel his self-leveling bucket to obtain the most efficient work position.

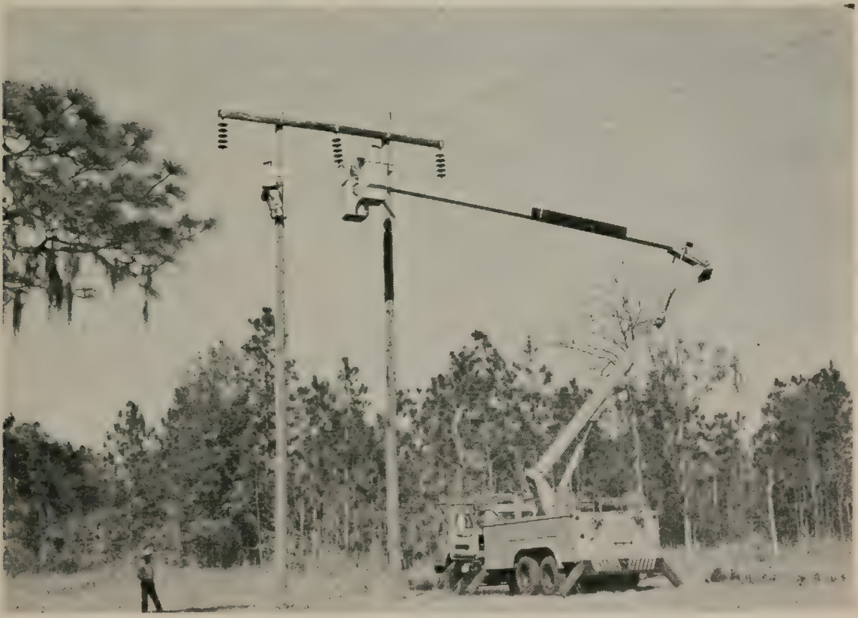


Fig. 5.

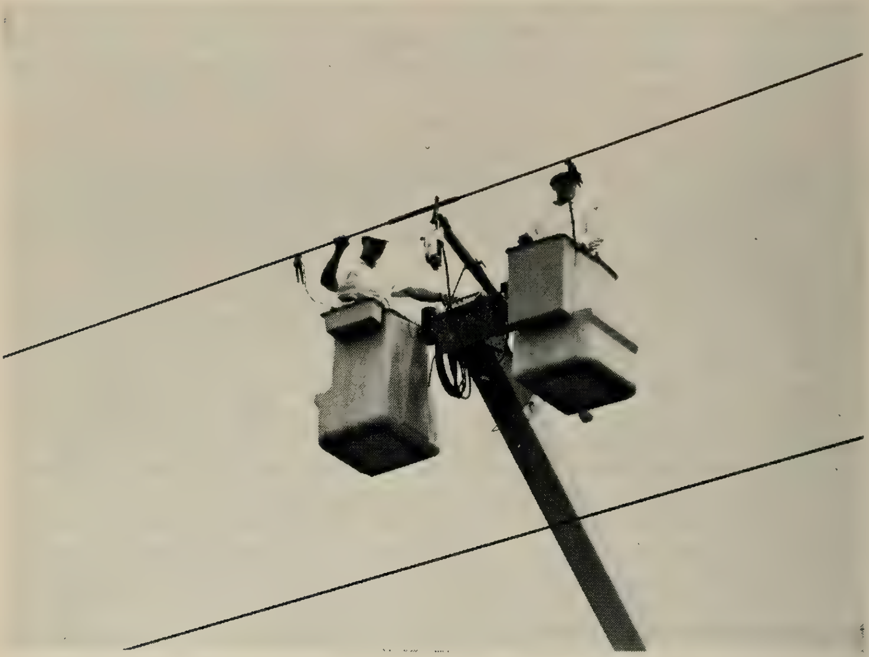


Fig. 6.

A 6-ft, pivoting, extendible fiber-glass boom, mounted between the two work buckets, supports wire spans and other loads to facilitate live-line work. Special tools are available for use on the boom.

The committee is indebted to T. B. Kirk, electrical engineer, Chicago, Milwaukee St. Paul & Pacific Railroad, for the following:

Figs. 7 and 8 illustrate two types of rail-highway work equipment built by the Milwaukee Road in its Tacoma Shops for transmission line and catenary maintenance. The equipment consists of two units with telescoping booms and two units with elbow-type booms. Total cost of each unit fully equipped is in the order of $17,000.

The equipment is operated on track by line crews without conductor-pilots. Work is scheduled and performed under a line-up, with the signal system in red.

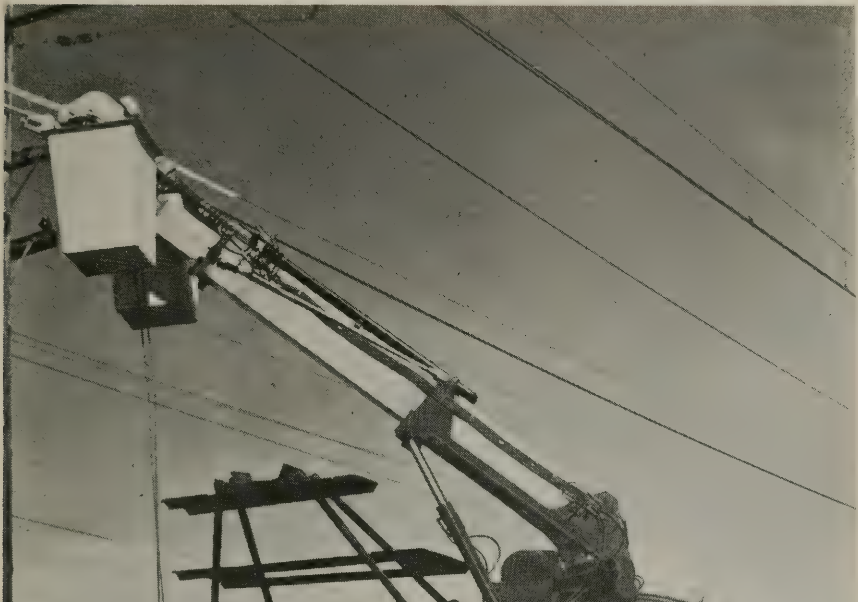


Fig. 7.

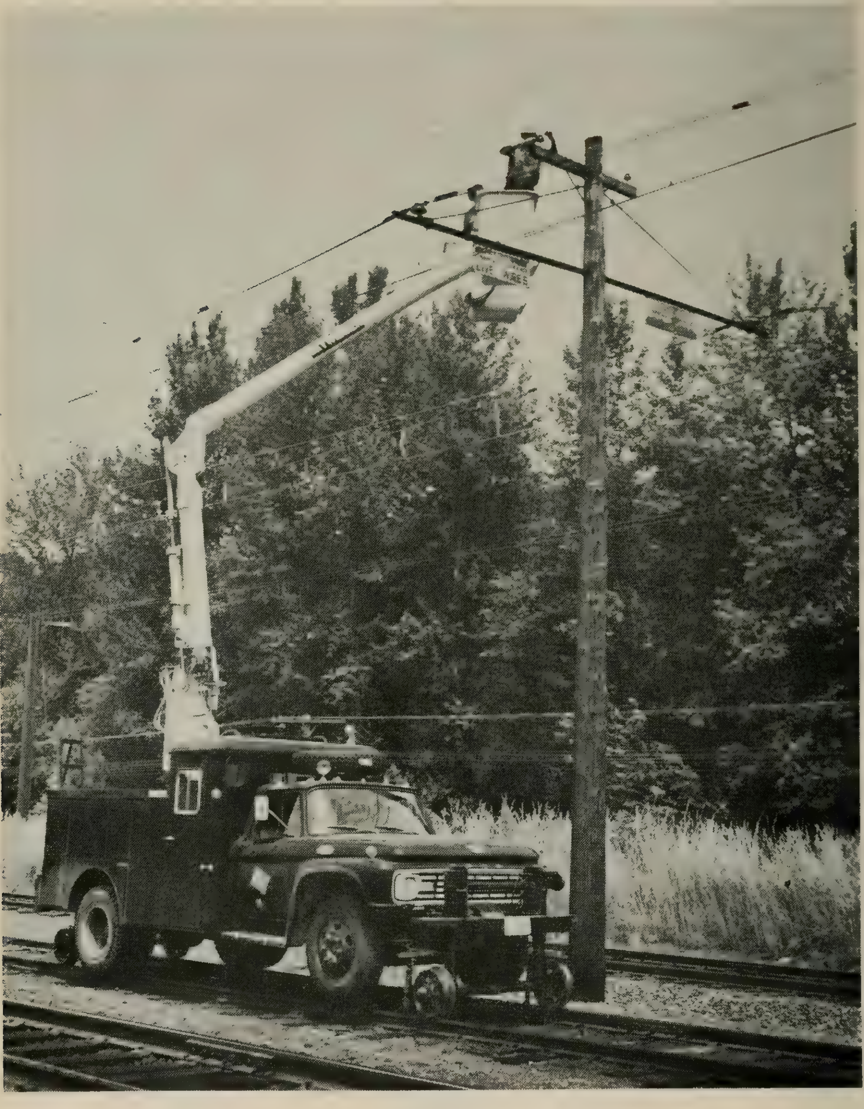
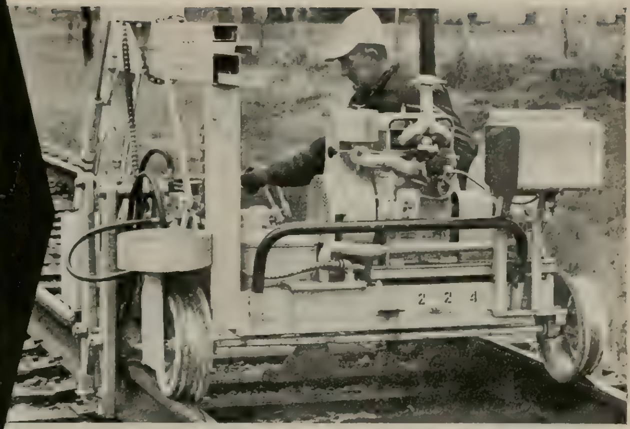


Fig. 8.

THIS MAN

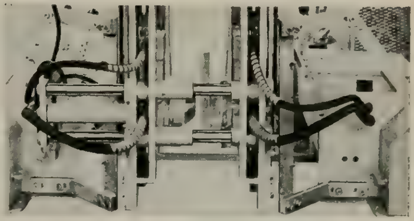


is saving thousands of man-hours tightening rail anchors with a RACINE

Loose rail anchors are as useless as weeds in the right-of-way. But an AnchorTight attachment on your Racine Anchor-Fast machine can reset old loose and misapplied anchors 100% tight to ties in seconds.

Four powerful, hydraulically-operated arms "squeeze" boxed anchors of any type with up to 50,000 lbs. pressure. The AnchorTight attachment easily replaces regular anchor applicator assembly; is raised and lowered hydraulically. Guide bars accurately position wearplates for fast operation. Adjusts to fit any rail from 90 to 155 lbs.

Write for details on the improved Racine Anchor-Fast applicator and AnchorTight attachment.



APPLIES UP TO 22 ANCHORS PER MINUTE. This new nipper assembly, with positive-alignment side guide-brackets, is one reason the Anchor-Fast is now more efficient than ever. Other improvements include a 300% increase in boxing pressure; elimination of 115 parts to simplify maintenance. Modernizing kits available for your present Anchor-Fast machines. RR-155

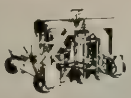
RACINE

RACINE HYDRAULICS & MACHINERY, INC.
Dept. F-94, Racine, Wisconsin

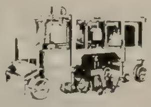
Unit Tamper

Portable Rail Drill

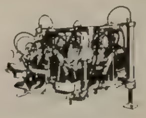
Portable Rail Saw



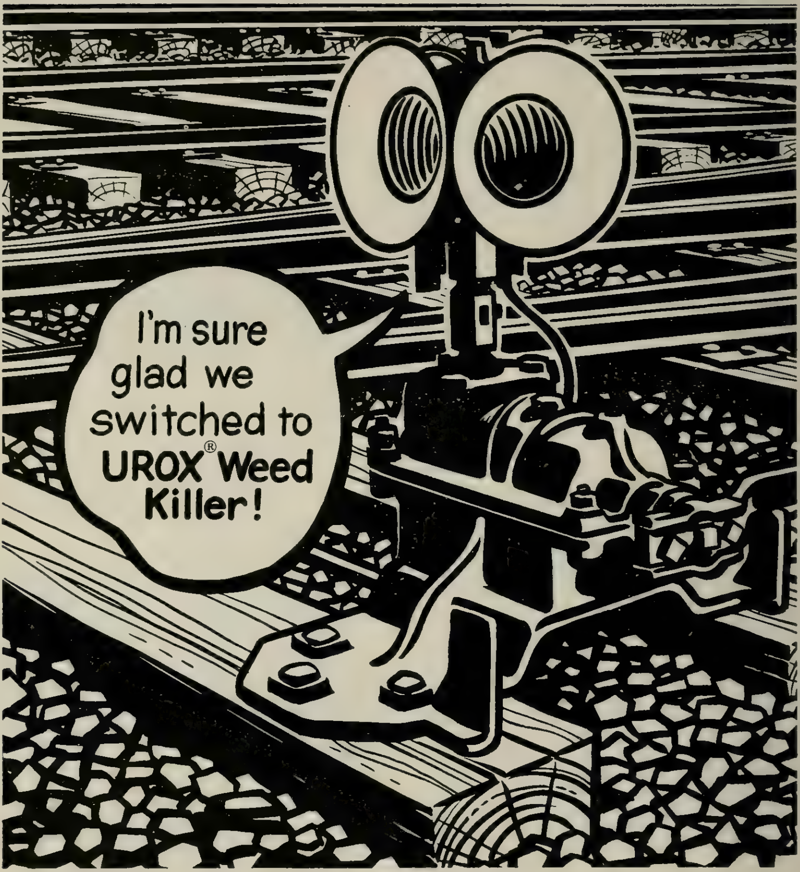
Anchor Applicator



Rail Drill&Saw



Production and Spot Tampers


I'm sure glad we switched to UROX® Weed Killer!

Switch to UROX Railroad Weed Killers to kill more weeds per mile per dollar. First application can last up to 18 months. Follow-up booster doses inexpensive. A complete line for all parts of the country, any application method, special weed problems. Write or phone.

Allied Chemical

GENERAL CHEMICAL DIVISION
P.O. Box 353, Morristown, N.J.

ROOTS AND LOADS TIES

LAYING WELDED RAIL

9' WIDE TRACK CLEANING BUCKET

SPEED SWING

MODEL 441

Developed and Built
for Railroad Maintenance

180° BOOM SWING

DOES ALL JOBS!

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
- Back Filler Blade
- Pull Drag Bucket
- 4 Cu. Yd. Snow Bucket
- Pile Hammer

Optional Attachment
Flanged Wheels, Hydraulically Controlled

PETTIBONE MULLIKEN CORPORATION

RAILROAD PMCO DIVISION
141 W. JACKSON CHICAGO 4, ILL.

80 Years of Service
to the Railroad Industry

Hubbard Super Service Alloy Spring Washers

Hubbard Super Steel Alloy Spring Washers

Hubbard Track Tools

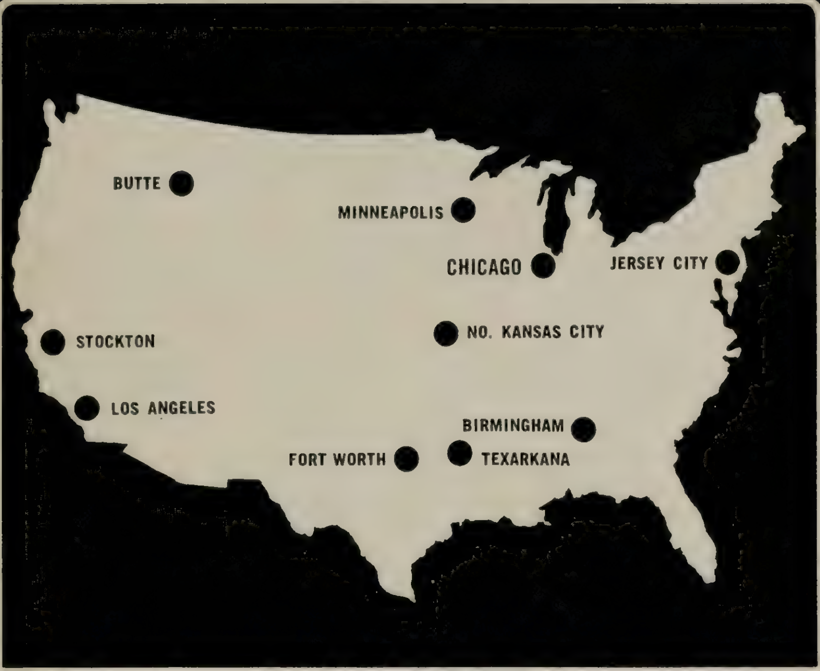
Hubbard Tool Division
UNIT RAIL ANCHOR CORPORATION

New York Pittsburgh Chicago

Unit Rail Anchor

UNIT RAIL ANCHOR DIVISION
UNIT RAIL ANCHOR CORPORATION

NEW YORK PITTSBURGH CHICAGO



U.S. BORAX OFFERS COMPLETE VEGETATION CONTROL SERVICE AND PRODUCTS THROUGHOUT THE COUNTRY

Our railroad herbicide specialists know your regional weed, soil, and weather conditions. They have an extremely wide selection of weed and brush killing chemicals. Now, with strategically located production facilities and the most efficient spray cars in railroading today, U.S. Borax is fully equipped to contract for any vegetation control program—and carry it out promptly, effectively and economically.

We would like an opportunity to prove it to you. Write today.

3456 Peterson Avenue, Chicago 45 • INdependence 3-6262

U.S. BORAX

WOODINGS-VERONA TOOL WORKS

Pioneer Manufacturers

of

HIGH GRADE TRACK TOOLS

and

SPRING WASHERS FOR TRACK

Since 1873

VERONA, PA. CHICAGO, ILL.

WOODINGS FORGE & TOOL COMPANY

Makers

of

WOODINGS RAIL ANCHORS

VERONA, PA. CHICAGO, ILL.

Notes on

Railroad Location and Construction Procedures from the School of Experience

By J. A. Given

A series of notes, comments, short-cut methods and "tricks of the trade" written by a railroad location engineer of many years of practical experience for the benefit of young engineers.

Price $0.50

AMERICAN RAILWAY ENGINEERING ASSOCIATION

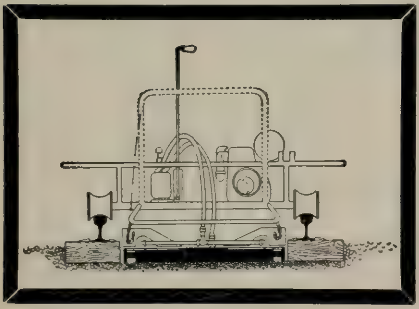
59 East Van Buren Street

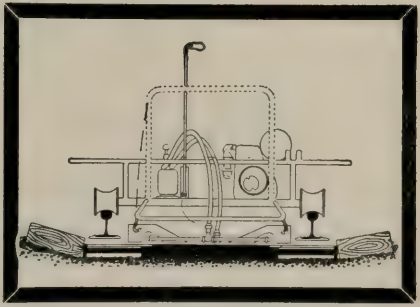
Chicago 5, Ill.

Model N U Tie Cutter

HERE IS THE WINNING TEAM

The Woolery NU Tie Cutter and the Woolery Tie-end Remover preserve the line and surface of the track and at the same time reduce the cost of tie renewals. Ties can be removed without trenching, jacking up track or adzing tops of rail-cut ties. With this team you simply cut both ends of tie, pry out center piece, insert in its place the tie-end remover and out go the tie ends pushed by the double acting, double ended hydraulic cylinder of the Tie-end remover.





FOR HIGHEST EFFICIENCY USE TWO TIE CUTTERS WITH ONE TIE-END REMOVER

WOOLERY MACHINE COMPANY
MINNEAPOLIS, MINN.

P. & M. PRODUCTS

- IMPROVED FAIR Rail Anchors

RAIL JOINT PRODUCTS

- Rajo Joints
- Insulated Joints
- Compromise Joints
- Fibre

MAINTENANCE EQUIPMENT PRODUCTS

- Meco Rail and Flange Lubricators
- Meco Rail Layers
- Meco Brush Cutters
- MACK Reversible Switch Point Protectors

PEERLESS EQUIPMENT PRODUCTS

- Draft Gears
- Rail Titan Batteries

IN CANADA:
The P. & M Company Ltd

552AB

PRODUCTS OF PROGRESS

POOR & COMPANY
Railway Products Division 80 E. Jackson Blvd., Chicago 4, Ill.

Assure lower maintenance costs,
better performance with...

TEXACO

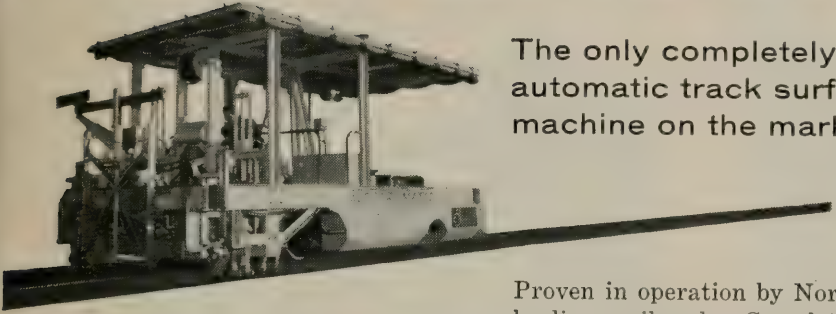
Petroleum Products and Systematic Engineering Service

TEXACO INC.
RAILWAY SALES DIVISION
135 East 42nd St., New York 17, N. Y.

NEW YORK • CHICAGO • SAN FRANCISCO • ST. LOUIS • ST. PAUL • ATLANTA

Tamper

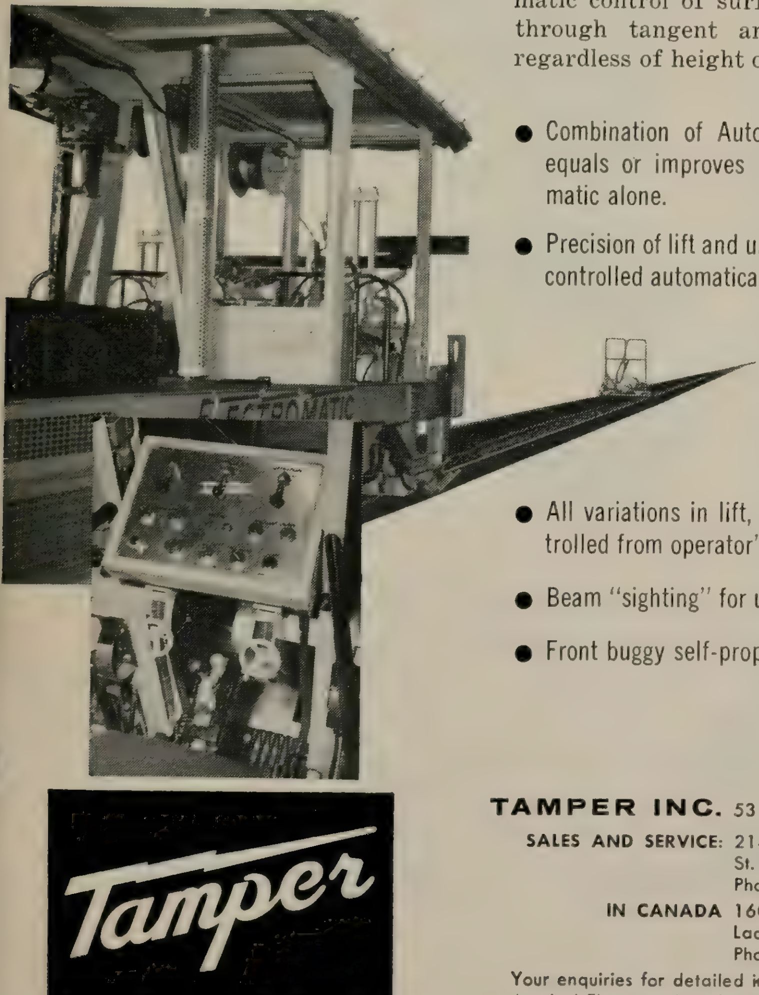
AUTOJACK ELECTROMATIC



The only completely automatic track surfacing machine on the market

Proven in operation by North America's leading railroads. Complete and automatic control of surface and cross level through tangent and curve territory regardless of height of lift.

- Combination of Autojack and Electromatic equals or improves production of Electromatic alone.
- Precision of lift and uniformity of compaction controlled automatically.



- All variations in lift, level and run-out controlled from operator's panel.
- Beam "sighting" for utmost precision.
- Front buggy self-propelled ahead of tamper.

Tamper

TAMPER INC. 53 Court St., Plattsburgh, N.Y.

SALES AND SERVICE: 2147 University Avenue
St. Paul 14, Minnesota
Phone: 645-5055

IN CANADA 160 St. Joseph Blvd.,
Lachine (Montreal), P.Q.
Phone: 637-5531

Your enquiries for detailed information or brochures on Autojack Electromatic and other track machines are invited.

THE DOUBLE U RAIL ANCHOR

ACHUFF RAILWAY SUPPLY CO.
ST. LOUIS, MO.

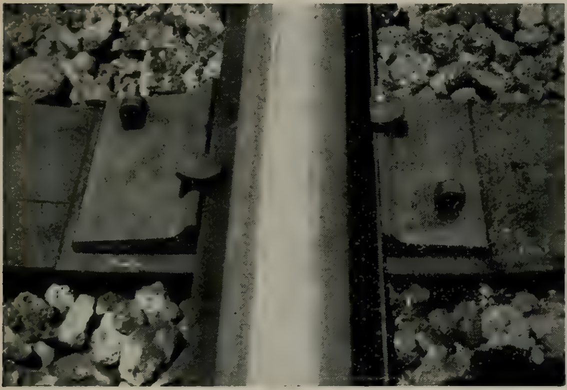
A COMPLETE LINE
OF SPRING WASHERS

THE NATIONAL LOCK WASHER CO.
Newark N. J., U. S. A.

E-x-t-e-n-d T-i-e L-i-f-e!

Hold Gage!

USE TIE PLATE *LOCK SPIKES*



One-piece Design

LOCK SPIKES hold tie plates firmly in place on cross-ties and bridge timbers.

LOCK SPIKES are quickly and easily driven, or removed, *with standard track tools.*

Driven to refusal, the spread shank is compressed by the walls of the hole. Tie plates are held against horizontal and vertical movement under spring pressure. Play between the spike and the hole is eliminated—abrasion and seating of tie plates is overcome.

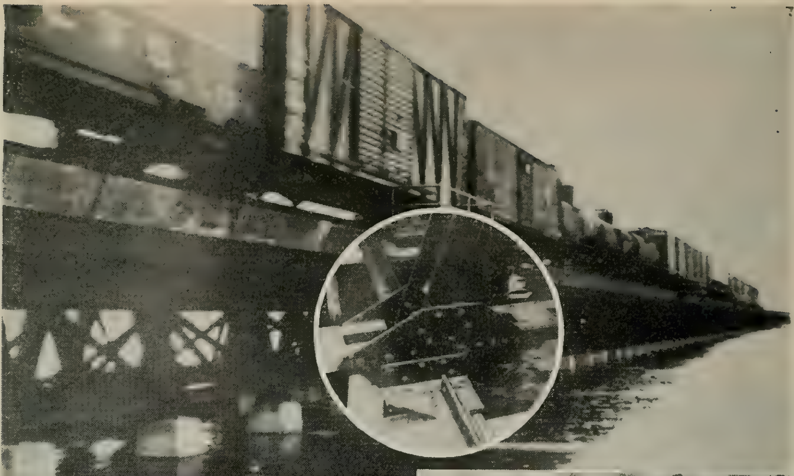
LOCK SPIKES hold their position in the tie, and redriving to tighten the plate is not required. They provide a quiet and strengthened track.

Annual cost of ties and maintenance expense is reduced by extending the life of ties and holding gage. Here is one answer to conservation of materials and labor. Write for free folder.

BERNUTH, LEMBCKE CO., INC.

420 Lexington Avenue, New York 17, N. Y.

Actual Size



The railroad bridge pictured has been protected satisfactorily with Brooks Protective Coating for over five years. The steel in the structure is subjected to atmospheric contamination, water action and winter snow and ice.

BROOKS

PROTECTIVE COATING FOR BRIDGES AND BUILDINGS

Corrugated metal buildings are subjected to corrosion and in some cases, severe corrosive conditions exist. Brooks Protective Coating will resist corrosion which causes deterioration to metal surfaces.

Easily applied by spray or brush.

Talk it over with the BROOKS OIL man near you!

The BROOKS OIL Company

Established 1876

General offices and U.S. plant: 3304 East 87th Street • Cleveland 27, Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton, Ontario

The Brooks Oil International Company: Exporters

PROGRESS REPORT

SPENO

Here are the up-to-date facts on the SPENO Ballast Cleaning and the SPENO Rail Grinding Services.

BALLAST CLEANING

SPENO Engineering and Research has developed a superior screening arrangement so that we are now using an improved Ballast Cleaner with greater efficiency.

RAIL GRINDING

Our Rail Grinding Service has been so well received — we now have *Three* Rail Grinding Trains to take care of the demand.

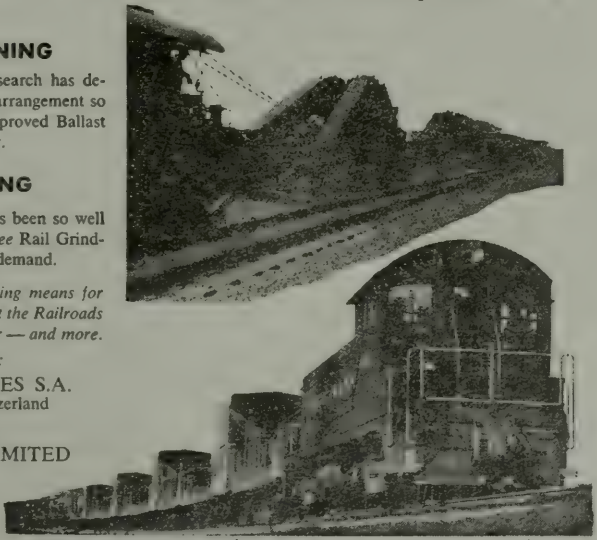
SPENO is constantly developing means for better service to make sure that the Railroads receive everything they pay for — and more.

Outside North American continent:

SPEMA RAIL SERVICES S.A.
Grand-Pont 2, Lausanne, Switzerland

Canadian Sales Representatives:

THE HOLDEN CO. LIMITED
614 St. James St., West
Montreal, Canada



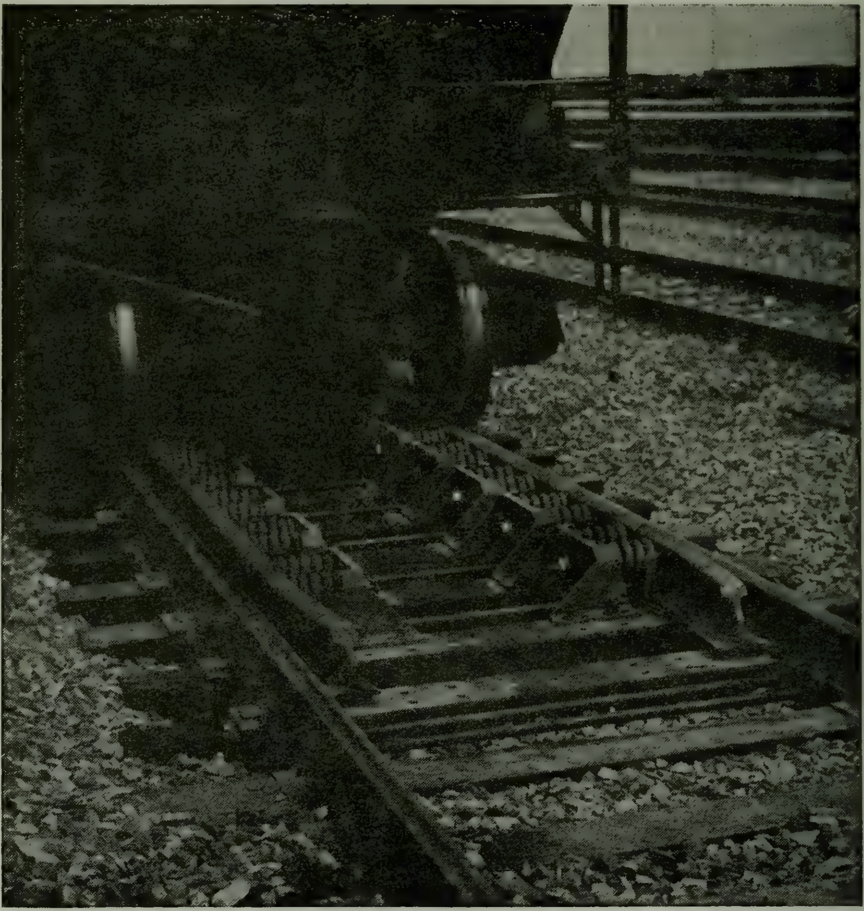
Just Ask the Railroads That have used us!

GEARED TO PROGRESS
P R I
MEMBER

FRANK SPENO RAILROAD BALLAST CLEANING CO., INC.

Clark Street
East Syracuse, N. Y.

306 North Cayuga St.
Ithaca, N. Y.



THE TRASCO CAR RETARDER

HUNDREDS IN SERVICE
IN CLASS YARD TRACK

TRACK SPECIALTIES COMPANY
P.O. BOX 729 WESTPORT, CONNECTICUT

ALPH B. PECK
3 TALBOT LA.
URBANA, IL.

American Railway Engineering Association—Bulletin

Bulletin 591
Proceedings Vol. 66*

February 1965

REPORTS OF COMMITTEES

4—Rail 445
5—Track 495
31—Continuous Welded Rail 507
1—Roadway and Ballast 521

The reports in this issue of the Bulletin will be presented to the 1965 Annual Meeting of the Association at McCormick Place, Chicago, March 23–25. Comments and discussion with respect to any of the reports are solicited, and should be addressed to the chairman of the committee involved, in writing in advance of the Meeting, or from the floor during the Meeting.

---

* The contents of this Bulletin and the other Bulletins of the Association from Bulletin 587, September–October 1964, to and including Bulletin 593, June–July 1965 (except Bulletin 592, March 1965), will constitute the Annual Proceedings of the Association, Vol. 66.

Copyright 1965, by American Railway Engineering Association

BOARD OF DIRECTION
1964–1965

President

T. F. Burris, Special Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718

Vice Presidents

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.
J. M. Trissal, Vice President, Illinois Central Railroad, Chicago, Ill. 60605

Past Presidents

C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania Railroad, Philadelphia, Pa. 19104
L. A. Loggins, Chief Engineer, Southern Pacific Company, Texas and Louisiana Lines, Houston, Tex. 77001

Directors

W. L. Young, Resident Vice President, Norfolk & Western Railway, Norfolk, Va.
T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va. 23213
C. E. Defendorf, Chief Engineer, New York Central System, New York, N. Y. 10017
John Ayer, Jr., Vice President—Operations, Denver & Rio Grande Western Railroad, Denver, Colo. 80217
A. L. Sams, Chief Engineer, Illinois Central Railroad, Chicago, Ill. 60605
D. C. Hastings, Assistant Vice President—Operations, Atlantic Coast Line Railroad, Jacksonville, Fla. 32202
B. B. Lewis, Professor of Railway Engineering, Purdue University, Lafayette, Ind.
H. M. Williamson, Chief Engineer System, Southern Pacific Company, San Francisco, Calif. 94105
H. E. Wilson, Assistant Chief Engineer—System, Atchison, Topeka & Santa Fe Railway, Chicago, Ill. 60604
J. S. Parsons, Engineering Consultant, Erie Lackawanna Railroad, Cleveland, Ohio. 44115
S. H. Poore, Office Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718
F. N. Beighley, Roadway Engineer, St. Louis–San Francisco Railway, Springfield, Mo. 65801

Treasurer

A. B. Hillman, Retired Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago.

Executive Secretary

Earl W. Hodgkins, 59 East Van Buren Street, Chicago, Ill. 60605

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Street, Chicago, Ill. 60605

Published by the American Railway Engineering Association, Monthly, January, February, March, November and December; Bi-Monthly, June-July, and September-October, at 2211 Fordem Avenue, Madison, Wis.; Editorial and Executive Offices,
59 Van Buren Street, Chicago 5, Ill.
Second class postage paid at Madison, Wis.
Accepted for mailing at special rate of postage for in Section 1103, Act of October 3, 1917, authorized on June 29, 1918.
Subscription $10 per annum.

Report of Committee 4—Rail

J. A. Bunjer, ***Chairman***
T. B. Hutcheson,
Vice Chairman
C. E. Morgan, ***Secretary***
D. T. Faries
R. C. Postels
Embert Osland
V. E. Hall
C. F. Parvin
J. B. Clark
A. P. Talbot
W. D. Almy
S. H. Barlow
G. V. Begany, Jr.
H. B. Berkshire
T. A. Blair (E)
B. Bristow
C. B. Bronson (E)*
R. M. Brown
T. F. Burris
R. E. Catlett, Jr.
M. W. Clark
C. J. Code
J. T. Collinson
C. A. Colpitts
C. O. Conatser
P. K. Cruckshank
W. J. Cruse
F. L. Etchison
O. E. Fort
J. H. Greason, Jr.
J. L. Gressitt (E)
C. E. R. Haight
C. J. Henry
C. C. Herrick
J. C. Jacobs
H. W. Jenkins
A. V. Johnston
K. K. Kessler
R. R. Lawton
Hugues Marquis
Ray McBrian
B. R. Meyers
F. R. Micheal
H. R. Moore
L. T. Nuckols (E)
J. S. Parsons
R. H. Patterson
G. C. Payne
G. L. P. Plow
R. B. Rhode
J. G. Roney
D. H. Shoemaker
H. F. Smith
W. A. Smith
G. L. Todd
E. H. Waring
J. H. Watts
C. E. Weller
D. J. White
H. M. Williamson
W. L. Young
Committee

(E) Member Emeritus.

* Died December 9, 1964.

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 4.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Chapter 4 of the Manual was reviewed during the year, but no changes are recommended.

2. Collaborate with AISI Technical Committee on Rail and Joint Bars in research and other matters of mutual interest.

   Progress report, presented as information .... page 447

   Appendix 2a—Report on Investigation of Failures in Control-Cooled Rails . page 447

3. Rail failure statistics, covering (a) all failures; (b) transverse fissures; (c) performance of control-cooled rail.

   Progress report, presented as information .... page 454

4. Rail end batter; causes and remedies.

   No report this year. Tests are being conducted on a new wire-feed process, and it is hoped that a report can be presented next year.

6. Joint bars: design, specifications, service tests, including insulated joints and compromise joints.

   Progress report, presented as information .... page 470

7. Metallurgical effect of rail cropping methods.
   Progress report, presented as information .... page 471
   Appendix 7a—Report on Rail Cropping by the Wet Abrasive Wheel Method at the Illinois Central Railroad Rail Welding Plant .... page 471

8. Causes of shelly spots and head checks in rail: Methods for their prevention.
   Progress report, presented as information .... page 479
   Appendix 8-a, Results of Inspections of Heat Treated and Alloy Rail Test Installations on Curves with Shelly Histories .... page 479
   Appendix 8-b, Shelly Rail Studies at the AAR Research Center .... page 484

9. Standardization of rail sections.
   Progress report, presented as information .... page 493

10. Service performance and economics of 78-ft rail, collaborating with Committee 5; specification for 78-ft rail.
    Progress report, presented as information .... page 494

THE COMMITTEE ON RAIL,
J. A. BUNJER, *Chairman.*

AREA Bulletin 591, February 1965.

MEMOIR

William Dudley Simpson

It is with deep sorrow that Committee 4 reports the death on March 20, 1964, of William Dudley Simpson, a long-time valued member of the Committee and the Association.

He served the Association as director in the years 1947 through 1949. In addition to his membership on Committee 4 from 1946 until 1961, his other committee activities included membership on Committee 3—Ties, 1938–1948, being vice chairman, 1941–1945, and on Committee 25—Waterways and Harbors, 1952–1957. He joined the Association in 1920 and became a Life Member January 1, 1955.

Mr. Simpson was born in Raleigh, N. C., on February 12, 1890. He entered the service of Seaboard Air Line Railroad on February 1, 1916, as draftsman, and progressed in various engineering capacities to the rank of chief engineer, which position he held from June 1, 1944, until his retirement on January 1, 1958. He was an officer in the United States Army in World War I, and gave valuable assistance in organizing the 722nd Railway Operating Battalion which served overseas in World War II.

He is survived by his widow, Mrs. Myrtle Gates Simpson of Largo, Fla., and one brother.

Report on Assignment 2

Collaborate with AISI Technical Committee on Rail and Joint Bars in Research and Other Matters of Mutual Interest

J. A. Bunjer (chairman, subcommittee), T. F. Burris, J. B. Clark, C. J. Code, C. A. Colpitts, D. T. Faries, O. E. Fort, C. C. Herrick, T. B. Hutcheson, Ray McBrian, B. R. Meyers, C. E. Morgan, Embert Osland, G. L. P. Plow, E. H. Waring, H. M. Williamson.

This committee sponsored one investigation, which was carried out under the direction of the AAR Research Center staff. The report on this work, entitled "Investigation of Failures in Control-Cooled Rail," is presented below as Appendix 2–a.

Appendix 2–a

Investigation of Failures in Control-Cooled Rails

During the period from August 1, 1963, to October 1, 1964, 13 failed control-cooled rails were submitted to the AAR Research Center for metallurgical examination, the results of which have been submitted to the railroad supplying the rail and to the rail producer. The failed rails are listed on Table 1 and include both service failures and detected failures.

All the specimens submitted were checked for metallurgical quality by means of cross sectional and longitudinal macrographs. Rail No. 132–1 was of a sound quality, but failed due to a shell, as shown on Fig. 1. Rail No. 132–4, shown on Fig. 2, showed a typical transverse fissure due to non-metallic inclusions. The failure due to a transverse fissure from shatter cracks in rail No. 135–1 is shown on Figs. 3 and 4. This rail was rolled in 1935, prior to the establishment of proper control-cooling. The effect of hot-torn steel in causing a transverse fissure is illustrated in Fig. 5 (rail No. 132–2). Other rail failures of interest submitted for investigation include one due to a base seam (Fig. 6) and another through a bolt hole (Fig. 7). A contributing factor in the failure from the base seam, rail No. 135–5, was an uneven bearing of the base on the tie plate. Investigation of the failure through the bolt hole in rail No. 135–6, showed that the hole was drilled through a brand, which is undesirable, but further study revealed that a heavy uneven bolt bearing in the direction of the crack caused the failure.

TABLE 1
SERVICE AND DETECTED FAILURES OF CONTROL-COOLED RAIL
(August 1, 1963 to October 1, 1964)

Lab. Failed Rail No.	Source of Failed Rail	Size of Rail	Producer (Mill)	Heat No. Rail Letter Ingot No.	Date Rolled	Type of Rail Failures	
						Service	Detected (Ver. by AAR)
132-1	N&W	131 lb RE	Carnegie Illinois	15H189-D-20	4-1947		C. F. & D. F. from shelling.
132-2	N&W	131 lb RE	Steelton	87171-B-4	3-1942		T. F. from hot torn steel.
132-3	C&NW	115 lb RE	Inland	21027-E-18	8-1952		T. F. from hot torn steel.
132-4	SAL	115 lb RE	Tennessee	856580-E-14	1951		T. F. from a non-metallic inclusion.
132-5	NP	115 lb RE	CF&I	15219-F-15	3-1956		No indication of undesirable metallurgical defects.
132-6	NP	115 lb RE	CF&I	10218-B-10	3-1956		No indication of undesirable metallurgical defects.
135-1	C&NW	90 lb	Illinois	49328-C-6	10-1935	T. F. from shatter cracks.	
135-2	SAL	132 lb RE	Steelton	89432-G-9	9-1950	C. F. & D. F. from shelling.	
135-3	N&W	131 lb RE	Steelton	89256-E-4	5-1942	T. F. from inclusions.	
135-4	MP	115 lb RE	Tennessee	898634-B-5	12-1962	No indication of undesirable metallurgical defects.	
135-5	MP	115 lb RE	Tennessee	291764-E-12	12-1962	Base seam.	
135-6	GN	115 lb RE	Inland	22166-H-6	5-1955	Failed from bolt hole. Hole drilled through the brand.	
136-7	CP	100 lb HF	Algoma	24534-B-19	7-1949	T. F. from hot torn steel.	

C. F.--Compound Fissure, T. F.--Transverse Fissure, D. F.--Detailed Fracture

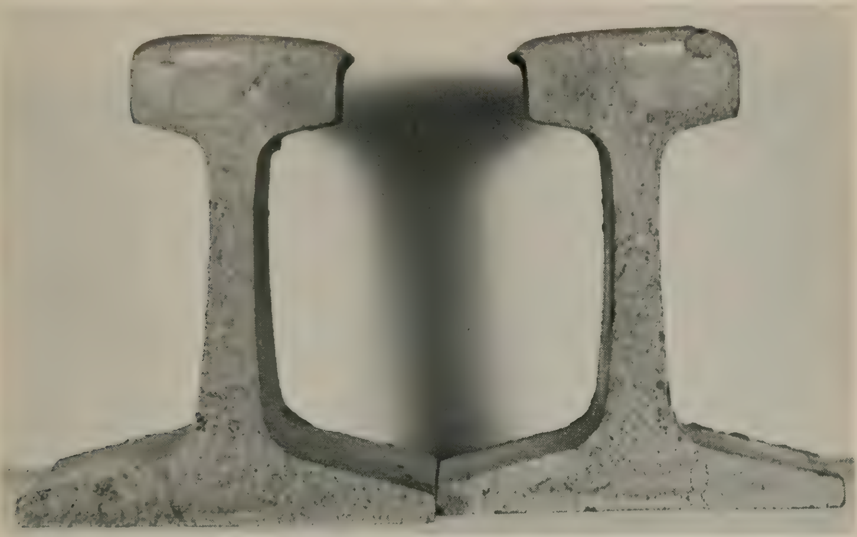


Fig. 1—Faces of the fracture of a rail with a Sperry-detected transverse defect.

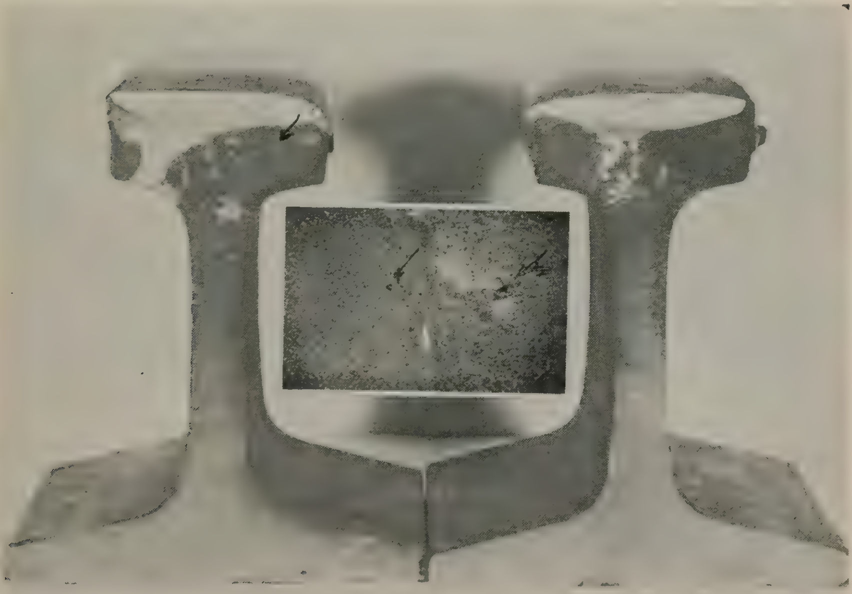


Fig. 2—Typical transverse fissure due to non-metallic inclusion. Arrow indicates the nucleus of the progressive failure. Insert is a photograph at 2¼× magnification of the non-metallic inclusion in the transverse fissure.

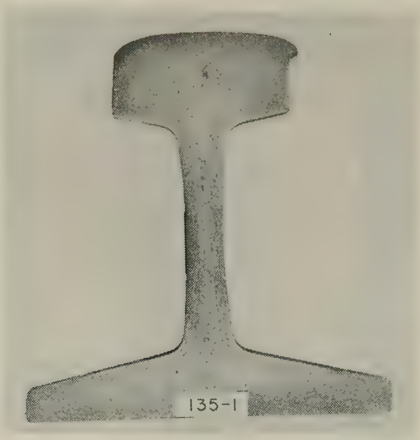


Fig. 3—Macrograph of a cross section from a rail that failed in service owing to transverse fissure from shatter cracks.

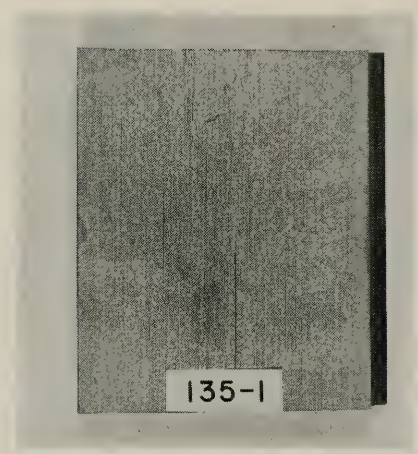


Fig. 4—Macrograph of a longitudinal section of the failed rail shown in Fig. 3.

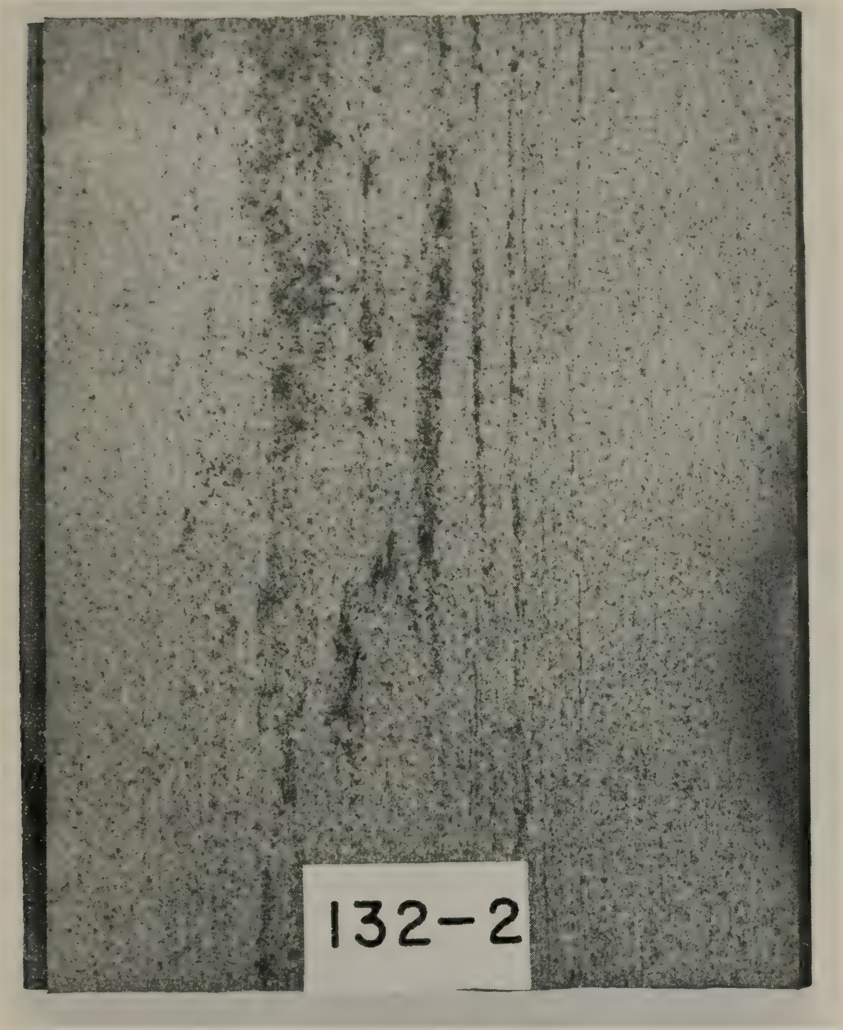


Fig. 5—Macrograph of a longitudinal section in the horizontal plane next to the fracture on specimen 267, showing porosity due to hot-torn steel.

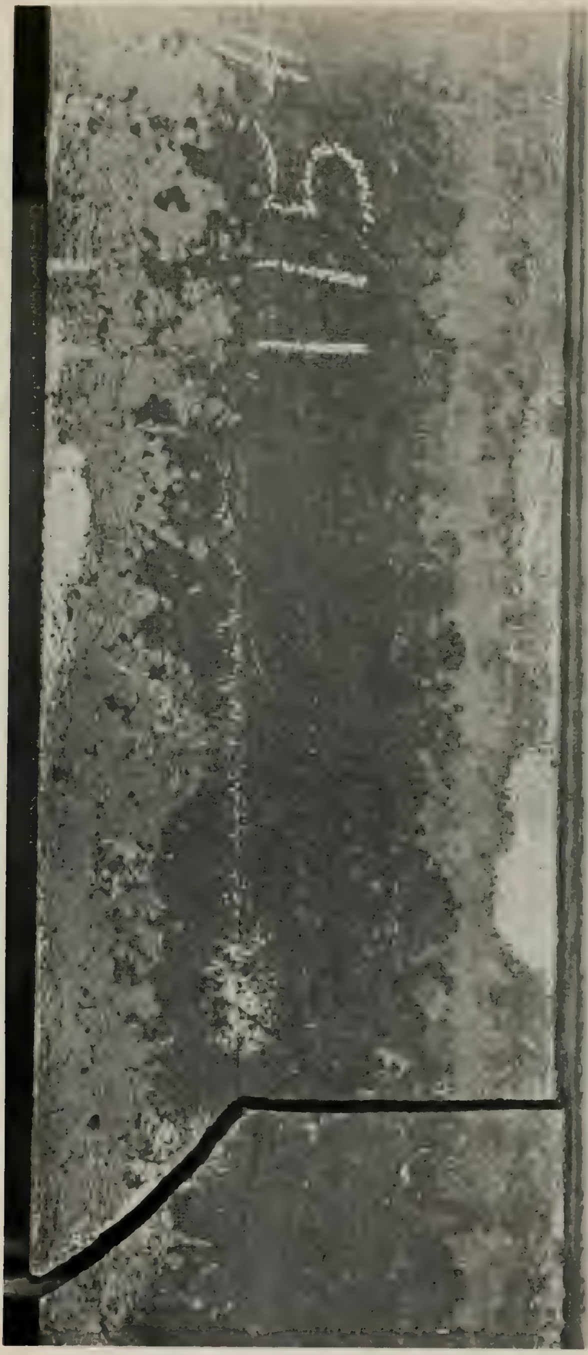


Fig. 6—Photograph of the bottom of the base of a rail that failed because of a base seam. Photo shows the break from the seam and the tie plate bearing.

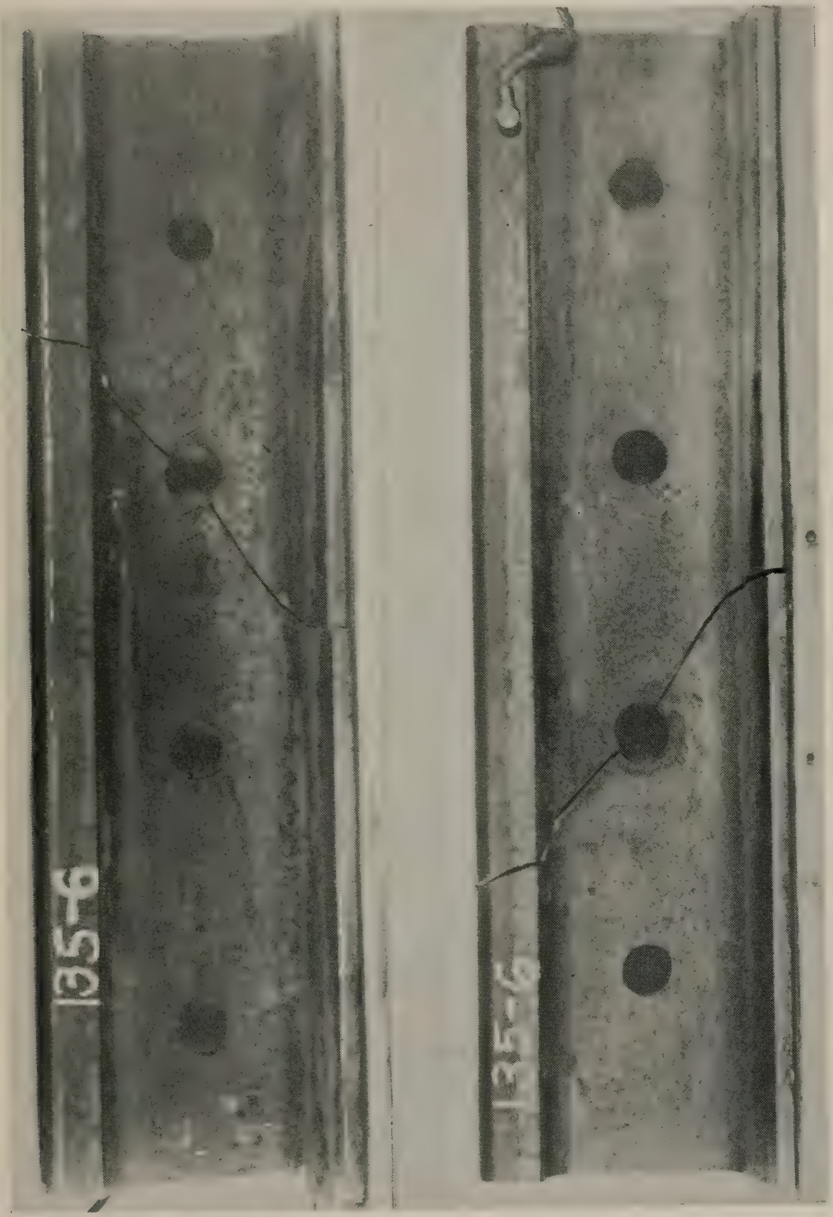


Fig. 7—Photograph of a service failure through a bolt hole of a 115 RE rail.

Report on Assignment 3

Rail Failures Statistics Covering (a) All Failures, (b) Transverse Fissures, (c) Performance of Control-Cooled Rail

D. T. Faries (chairman, subcommittee), S. H. Barlow, B. Bristow, J. A. Bunjer, C. O. Conaster, C. E. R. Haight, T. B, Hutcheson, H. W. Jenkins, A. V. Johnston, K. K. Kessler, F. R. Micheal, H. R. Moore, C. E. Morgan, Embert Osland, C. F. Parvin, D. H. Shoemaker, H. F. Smith, W. A. Smith, A. P. Talbot, W. L. Young.

These statistics are based on the rail failures reported up to December 31, 1963, and are submitted as information. They include the service and detected failures reported by 47 railroads on all of their main-track mileage, which constitutes approximately 90 percent of the main track of Class I railroads in the United States. This report is a technical service of the Association of American Railroads Research Department, W. M. Keller, vice president—research, and was prepared by M. J. Wisnowski, metallurgical assistant, under the direction of G. M. Magee, director of engineering research.

Although there have been some changes in the mileage reported on due to various reasons as explained in the footnote to Table I, nevertheless the amount of change is relatively small compared to the total mileage reported and does not, therefore, materially detract from the values of these statistics.

The accompanying tables and diagrams indicate the extent of control of the transverse-fissure problem that has been obtained by the use of control-cooled rail and detector car testing, give data on the quality of each year's rollings for the various mills, and show the types of failures that are occurring on the various railroads as related to the mill producing the rail.

Transverse-Fissure Failures

Data on service transverse-fissure failures and detected transverse defects are given in Table 1 and Fig. 1. Table 1 shows this information for individual roads for the 10-year period 1954 to 1963, incl. It will be noted that there was no significant change in the total number of service failures and detected failures for 1963 as compared with 1962. For individual roads there were no outstanding changes in service failures for 1963. A few roads reported large increases in the number of detected defects, but these increases were offset by a reduction in detected defects generally and by the fact that the Southern Railway did not report this year, so the total remained about the same for 1963.

The number of track miles tested by detector cars, according to data received from reporting roads, decreased from 206,291 in 1962 to 199,401 in 1963, as indicated in the table at the top of page 455.

The complete story on service and detected failures is given in Fig. 1. The significance of this figure was explained in detail in a previous report (Vol. 61, page 845) and will not be repeated. Lines "C" and "D" were discontinued in 1958 because they had served their purpose. The most important line in Fig. 1, "A", is for service transverse fissures and shows the improvement that has been effected since 1943 by the use of control-cooled rail and detector-car testing.

Year Tested	*Number of Roads Reporting*	*Track Miles Tested by Detector Cars*
1953	59	212,280
1954	56	201,134
1955	56	186,322
1956	50	196,882
1957	57	212,082
1958	54	216,731
1959	53	212,833
1960	53	206,731
1961	48	193,516
1962	50	206,291
1963	46	199,401

Mill Performance

The number of service and detected rail failures that occur during the first five years of service has been considered to be a good criterion of mill performance and the quality of rail as manufactured. Fig. 2 shows these failures for each year's rollings from 1908 to 1957, incl. An explanation of the large decrease in number of failures throughout this period was given in the 1963 report. It is gratifying to note that the number of failures is continuing at the low level established in the 1955 rollings.

Fig. 3 shows the control-cooled rail-failure rates cumulatively for the rollings from 1953 to 1962, incl., by the different mills. In making comparison between mills as reflected in this figure it is important to recognize that because of service conditions on roads served by the various mills, these failure data should not be taken as necessarily indicative of the rail quality. A detailed explanation of the reasons for the difference in failure rates for the different mills and different year's rollings was given in the 1963 report for rollings up to and including the 1960 rollings. The only increase compared to last year's report that deserves comment is in the 1961 Dominion rollings. Although the failure rate of 5.0 looks large, it actually represents only 6 in 120 mile years. The failure rate for the 1962 rollings is low for all mills.

The only comment to be made on Table 2, showing the amount of new rail rolled each year for the reporting roads, is that the amount continued relatively small during 1962 because of unfavorable business conditions for the railroads. The amount of 273,944 net tons does not represent all of the 1962 rollings for these roads because rollings for any railroad from one mill of less than 500 tons are not included.

Fig. 4 and Table 3 from which the figure is derived show not only the effect of years of service on rail failures but also a comparison of the reduction in failure rates effected with the new rail sections introduced in 1947. This will be discussed more fully later.

Types of Failures

Table 5 shows the accumulated service and detected failures per 100 track miles in the rollings from 1953 to 1962, incl., that have occurred up to December 31, 1963, by types of failures and by mills. Compared to last year's data, the failures per 100 track mile years for the different types of failures are the same or only slightly increased except for the CF and DF classifications which increased from 1.44 to 1.73. Web-in-Joint failures comprise 25 percent of all failures and the CF's and DF's, 45 percent. Both of these types of failure are considered to be due to design or operating conditions rather than rail quality. The large number of CF's and DF's from Carnegie–E. T. rollings occurred on the Norfolk & Western due to heavy traffic and curvature and the large number from Colorado occurred on the Denver & Rio Grande Western, Southern Pacific and Union Pacific for the same reasons. The relatively large number of VSH and Other Head failures in Algoma rollings occurred in rollings prior to 1956. The large number of Web-in-Joint failures in the Algoma, Colorado, and Dominion rollings are evidently due to design, as relatively few failures of this type have been reported for the new sections shown in Table 5a.

The extent to which the "new rail sections" adopted in 1947 have affected the number of failures of each type is indicated in the following tabulation, which shows the accumulated failures in the "old sections" in the 1938 to 1947 rollings, incl., which were mostly control-cooled rail; in the 1953 to 1962 rollings, incl., which include mostly new but some of the old sections; and in the 1953 to 1962 rollings, incl., which include the new sections only as shown in Table 5a.

	Accumulated Failures Per 100 Track Mile Years		
	Old Sections (1938–1947)	*All Sections (1953–1962)*	*New Sections (1953–1962)*
TF—Verified by University of Illinois	0.02	0.003	0.003
CF and DF	1.73	1.73	1.99
VSH	0.58	0.30	0.09
HSH	0.53	0.20	0.16
Other Head	0.52	0.51	0.25
Broken	0.75	0.06	0.06
Web-in-Joint	3.34	0.95	0.18
Web—Other	1.47	0.08	0.04
Base	0.30	0.04	0.02
All Types	9.24	3.89	2.79

Comparing the failure rates in the "New Sections" with those in the "Old Sections" the following comments may be made:

TF—Since the old sections were mostly control-cooled rail also, the failure rates are low in both old and new sections.

CF & DF—This is the only classification in which there has been an increase in failure rates with the new sections. It was hoped that the change in the top contour of the rail at the gage corner would reduce the amount of shelling from which most of the CF's originate, but evidently the increase in wheel loads and train speeds has more than offset any benefit so effected.

VSH, HSH, Other Head—The substantial reductions in these classifications are attributed to better manufacturing processes.

Broken—The reduction in this classification is probably due to a combination of increased rail size, better design, improved rail quality and better maintenance practices for track and equipment.

Web-in-Joint, Web, Other—The very large reductions in these classifications is attributed to the new rail designs and new bolt hole spacing adopted in 1947.

Base—These failures are generally due to seams in the base, and improved rail quality and track maintenance are probably responsible for the reduction effected.

The volume of traffic has not changed enough between the two 10-year periods to have had much influence on the relative rates of rail failures.

Table 6 shows the accumulated failures in the rollings from 1953–1962, incl., by mills, roads and types of failure. The data shown in this table are particularly helpful in determining whether rail failures reported are due to mill quality or service conditions. It is interesting to note that 82 percent of the total failures have occurred on four railroads. The number of CF's and DF's on the Union Pacific has been greatly reduced over the number reported several years ago.

Table 7 shows the service and detected failures in the rail web within joint bar limits. Comparing these results with those reported last year, it will be noted that the number of joints reported inspected with defect-detecting instruments decreased from 18,628,525 in 1962 to 15,451,991 in 1963. Most of this decrease could be accounted for by the lack of a report from the Southern Railway which road reported 2,870,721 joints inspected in 1962. There was an increase in the number of detected web failures from 18,867 in 1962 to 22,255 in 1963, or 18 percent, and in the number of service web failures from 11,380 in 1962 to 12,145 in 1963, or 7 percent. These increases would have been greater if the Southern Railway failures could have been included. The total number of detected and service failures of this type reported in 1963 was 34,400, or approximately one per 5.7 miles of main track.

Professor R. E. Cramer at the University of Illinois had examined rail failures submitted each year by the railroads which are thought to be transverse fissures until his retirement on October 1, 1963. Since then this work has been continued at the AAR Research Center. These are reported again in Table 8. It can be noted that no transverse fissure from a shatter crack has been found in the rollings since 1951 indicating that this problem is under control. The transverse fissures from hot torn steel and inclusions are due to mill practice and can be kept to a minimum by proper quality control. No transverse fissures from these causes has been found in rail rolled after 1955.

Table 9 presents a sampling of the welded engine burns and failures on a few railroads that have a record of these failures. It can be noted that only 6 failures were reported out of 887,312 in track, and 53,105 engine burns were welded in 1963. From the number of roads involved, these figures indicate the practice of welding engine burns is showing good service performance. This confirms the extensive laboratory tests made several years ago which indicated that although a welded engine burn was more likely to develop a failure than an unburned rail, it was less likely to develop a failure than an engine burn which had not been welded. The use of care and a good procedure in welding engine burns is, of course, an important factor in obtaining good service performance.

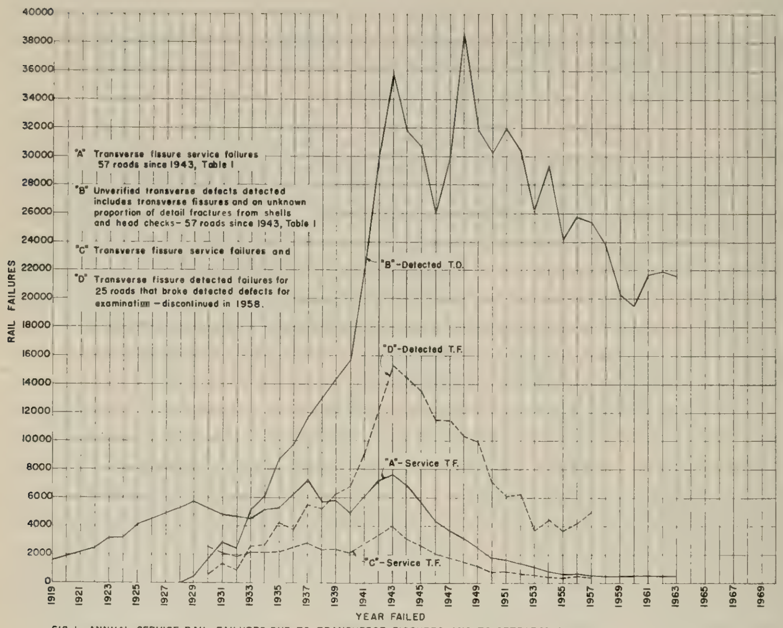


FIG I - ANNUAL SERVICE RAIL FAILURES DUE TO TRANSVERSE FISSURES AND TO DETECTED TRANSVERSE DEFECTS AS REPORTED BY ALL RAILROADS

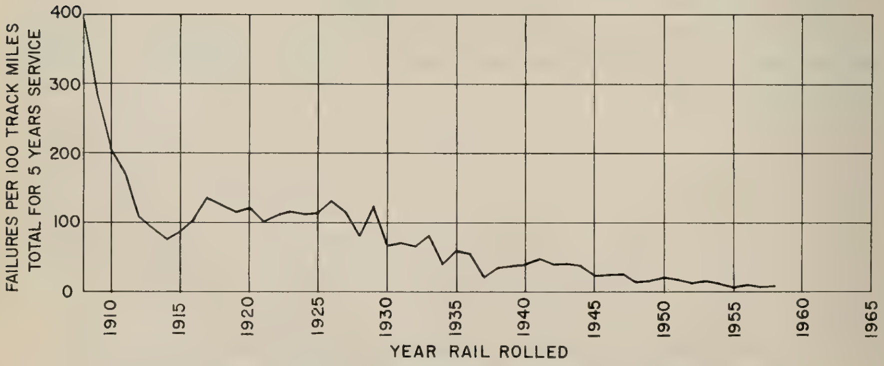


FIG. 2 - SERVICE AND DETECTED FAILURES IN UNITED STATES AND CANADA

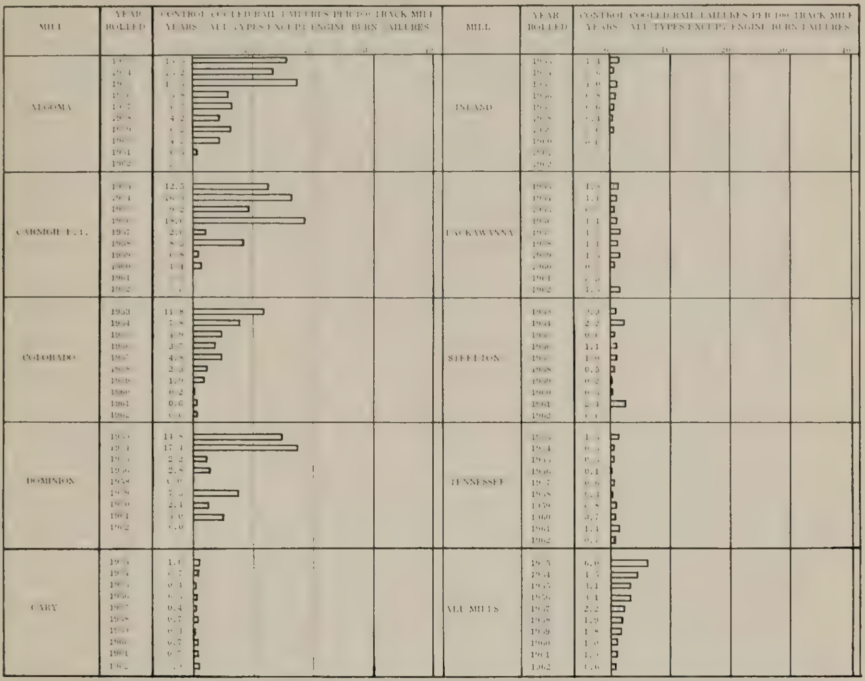


FIG. 3 - CONTROL COOLED RAIL FAILURE RATES TO DECEMBER 31, 1963 BY MILLS - ALL TYPES EXCEPT ENGINE BURN FAILURES - SERVICE AND DETECTED

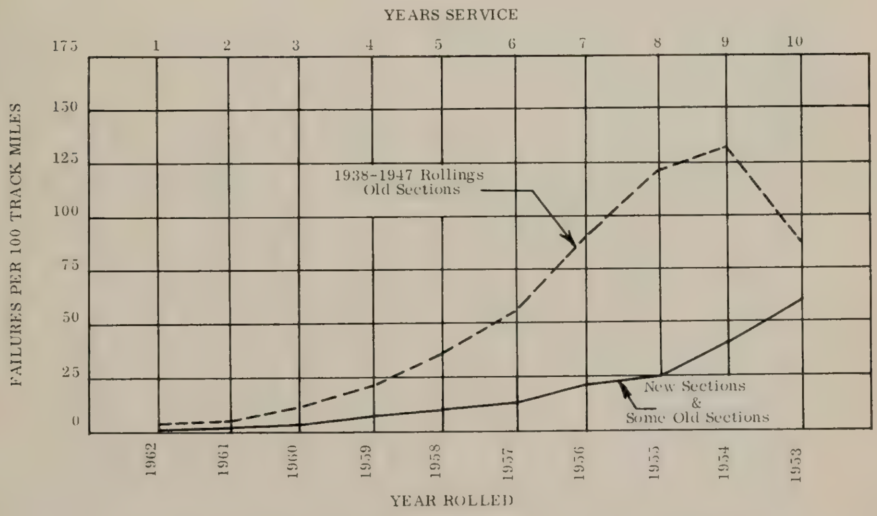


Fig. 4 - Control Cooled Rail Failures to December 31, 1963 Per 100 Track Miles - All Types Excluding Engine Burn Fractures - Service and Detected.

NOTE: Decline in failure rate in old sections occurred during 9th and 10th years of service due to rollings having a large number of failures being removed and no longer included in the reports.

TABLE 1 - SERVICE FAILURES FROM TRANSVERSE FISSURES AND DETECTED FAILURES FROM TRANSVERSE DEFECTS BY RAILROADS AND BY YEAR FAILED - ALL ROLLINGS BY ALL PROCESSES

	Service Failures											Detected Failures										
Year Failed	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Total	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Total
AT&SF	19	16	15	7	9	7	12	18	6	6	115	908	1278	1120	1178	1423	917	1166	1249	1687	1147	12073
ACL	4	1	3	2	5	6	9	5	6	4	45	851	836	594	648	565	603	590	428	547	625	6287
B&O	76	59	150	150	102	95	101	59	78	98	968	696	650	752	909	670	784	779	777	451	556	7024
B&OCT	4	5	12	6	9	6	6	3	0	--	51	3	2	1	2	3	1	1	3	1	----	17
Ban Aroos	1	0	0	0	0	0	1	0	0	0	2	22	16	33	23	18	14	22	99	20	29	296
B&LE	0	1	1	1	0	0	0	0	0	0	3	0	26	27	45	13	31	11	7	32	25	217
B&A	--	--	1	1	1	2	3	(a)	(a)	(a)	8	---	---	52	41	22	12	20	(a)	(a)	(a)	147
B&M	25	25	15	19	17	10	1	1	4	1	118	284	300	282	250	50	154	122	253	320	148	2163
CP	31	39	26	20	16	20	16	18	16	15	217	1805	1375	1258	976	1210	1084	563	945	1246	836	11298
C. of Ga.	10	4	5	0	0	1	0	0	0	--	20	367	570	426	694	685	637	859	2027	1295	---	7560
C&O (Sys.)	16	39	19	52	30	22	13	13	19	21	244	562	383	523	200	497	346	194	236	368	391	3700
C&EI	19	14	14	1	0	0	0	0	0	29	87	206	152	136	253	154	181	190	219	124	300	1915
C&NW	62	73	38	38	37	29	27	27	26	10	367	861	778	807	675	838	1020	1037	988	938	787	8729
CB&Q	17	12	8	7	5	10	7	10	13	10	99	940	922	795	825	293	277	381	261	223	394	5311
CI&L (Monon)	5	0	0	0	4	0	0	0	2	1	12	75	81	124	66	69	36	117	68	53	27	716
CMStP&P	30	21	21	11	16	12	6	5	10	3	135	928	810	893	864	749	668	679	576	649	438	7254
CRI&P	27	22	21	13	8	8	13	3	9	9	133	412	528	744	1076	228	239	339	329	256	326	4477
C&S (b)	2	0	1	0	1	3	0	2	1	1	11	308	133	140	124	114	117	98	78	87	72	1271
Cartier	--	--	--	--	--	--	--	--	0	0	0	--	--	--	--	--	--	--	--	0	0	0
D&H	0	0	0	0	0	0	0	0	1	0	1	314	97	219	121	180	123	65	69	310	165	1663
D&RGW	6	3	4	0	5	0	0	0	0	0	18	455	514	502	436	310	449	406	275	439	272	4058
Erie-Lack	9	10	15	3	10	9	13	5(c)	2(c)	9(c)	85	469	270	317	275	180	161	272	668(c)	863(c)	1033(c)	4508
FEC	0	4	0	0	0	0	0	0	(d)	(d)	4	175	129	73	87	61	77	27	28	(d)	(d)	657
GTW	6	4	9	1	8	2	0	0	0	0	30	74	82	67	99	117	77	118	181	114	147	1076
GN	45	42	29	24	26	23	14	4	17	11	235	1163	914	1362	1262	583	695	642	872	359	419	8271
IC (Sys.)	25	10	15	5	6	6	5	4	8	8	92	908	830	826	782	593	602	521	715	574	900	7251
JCL (NY&LB)	9	7	7	5	9	0	--	--	0	3	40	56	83	75	71	56	90	--	--	132	55	618
KCS	8	1	2	10	2	3	10	4	1	6	47	58	47	54	37	42	33	72	33	39	72	487
L&HR	0	0	0	0	0	0	0	0	0	0	0	6	6	1	3	4	5	0	11	2	7	45
L&NE	2	0	0	2	1	1	0	0	(e)	(e)	6	14	15	0	15	8	24	25	0	(e)	(e)	101
LV	2	8	2	8	3	2	3	1	3	1	33	123	94	147	72	57	69	32	39	52	74	759

TABLE 1 (Continued)

	Service Failures											Detected Failures										
Year Failed	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Total	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Total
LI	0	12	--	9	4	--	0	0	10	16	51	11	49	--	13	19	--	14	15	35	53	212
L&N	29	29	27	30	24	25	23	13	9	14	223	592	696	589	606	760	646	816	776	867	658	7006
Me. Cent.	--	1	8	5	1	1	3	3	0	1	23	--	36	36	43	45	28	44	68	46	19	365
MStP&SStM	0	10	1	1	2	0	4	4	7	15	44	632	48	68	67	59	94	61	57	75	70	1231
MKT	8	8	18	3	1	1	0	2	4	0	45	259	212	245	187	153	174	245	796	964	2146	5381
MP Lines	23	11	6	11	16	9	18	15	18(f)	43(f)	170	783	725	594	574	608	555	484	450	330(f)	473(f)	5576
NC&StL	1	1	2	0	(g)	(g)	(g)	(g)	(g)	(g)	4	3	6	10	7	(g)	(g)	(g)	(g)	(g)	(g)	26
NYC (Sys.)	114	59	95	63	66	39(h)	28(h)	31(h)	64(h)	54(h)	613	1612	508	956	1152	841	584(h)	348(h)	392(h)	296(h)	1085(h)	7774
NYC&StL	9	7	6	4	7	4	6	--	--	--	43	54	39	41	32	11	56	33	--	--	--	266
NYNH&H	4	5	4	2	1	1	0	5	0	2	24	56	62	81	118	40	42	74	14	7	4	498
NYO&W	6	1	3	(i)	(i)	(i)	(i)	(i)	(i)	(i)	10	182	28	37	(i)	(j)	(i)	(i)	(i)	(i)	(i)	247
N&W	4	3	7	3	3	4	5	4	2	4	39	135	103	166	403	248	478	389	598	554	418	3492
NP	0	1	9	4	7	3	0	0	0	0	24	429	339	136	381	373	269	203	133	167	203	2933
PRR	76	67	129	95	51	46	48	61	51	35	659	1574	1600	1880	1783	1810	1430	994	1382	1647	1532	15632
P&LE	0	0	0	0	0	0	0	0	0	0	0	22	26	10	9	7	7	1	2	6	9	99
QNS&L	--	--	--	--	--	--	--	0	0	--	0	--	--	--	--	--	--	--	14	24	--	38
Reading	0	0	0	0	5	0	0	0	0	0	5	460	271	290	274	299	297	351	332	332	298	3204
RF&P	0	1	0	0	0	0	0	0	1	0	2	25	24	18	18	23	12	20	10	9	38	197
Rutland	2	0	3	4	2	3	2	2	(j)	(j)	18	0	0	0	0	0	0	0	0	(j)	(j)	0
StL-SF	5	6	7	3	1	4	0	0	0	0	26	346	309	568	1674	2145	287(k)	198	189	603	328	6647
SAL	12	9	6	10	17	15	19	8	14	22	132	344	300	253	259	257	230	317	249	221	243	2673
SP	63	55	38	23	13	20	23	167	49	42	493	728	794	934	833	623	368	289	782	925	2052	8328
Southern	41	32	20	24	36	19	30	6	19	--	227	2157	1732	1442	1263	1579	1225	1208	1584	1188	--	13378
T&NO	28	16	1	0	4	17	31	(l)	(l)	(l)	97	708	456	463	353	470	115	182	(l)	(l)	(l)	2747
T&P	6	3	2	5	4	2	5	--	(m)	(m)	27	115	58	57	49	35	77	60	--	(m)	(m)	451
UP	18	10	7	1	5	3	0	0	1	2	47	5003	4074	4044	3113	3421	3640	3722	2517	2214	2155	33903
Virginian	0	0	3	7	0	(n)	(n)	(n)	(n)	(n)	10	41	57	66	84	197	77(n)	(n)	(n)	(n)	(n)	522
W. Md.	4	0	2	0	0	0	1	3	1	1	12	59	105	84	35	33	86	59	37	203	525	1226
ALL ROADS	913	767	837	693	600	493	506	506	482	497	6294	29376	24578	25718	25439	23848	20303	19460	21831	21894	21554	234001

- No report received
(a) Incorporated with the New York Central
(b) Includes the FW&D failures
(c) Merged with the DL&W Railroad forming the Erie-Lackawanna Railroad Company
(d) F.E.C. did not report because of a strike by the non operating employees
(e) L&NE did not report because of bankruptcy November 1, 1961
(f) Merged with the T&P Railroad
(g) Merged with the L&N Railroad
(h) Includes B&A, NYC Southern District (CCC&STL, P&E), NYC (New York District); NYC (Eastern District); NYC (Western District) and NYC (Northern District)
(i) Ceased operations 3-29-57
(j) Rutland Railroad closed down by strick during entire year 1963.
(k) Includes engine burn fractures
(l) Merged with the SP Company to become Southern Pacific Company. Texas and Louisiana Lines
(m) Merged with the MP Railroad
(n) Merged with the N&W Railroad

TABLE 2 - TONS OF RAILS AND TRACK MILES OF EACH YEAR'S ROLLINGS 1953 - 1962 INCL. REPORTED BY 47 RAILROADS

Year Rolled	OH CONTROL COOLED ONLY	
	NET TONS	TRACK MILES
1953	1,207,782	5,683.69
1954	823,831	3,833.60
1955	883,125	4,085.60
1956	865,017	4,024.40
1957	814,723	3,480.30
1958	401,532	1,855.90
1959	458,260	2,131.10
1960	364,097	1,674.60
1961	290,210	1,339.50
1962	273,944	1,252.60
TOTAL	6,382,521	29,361.29

TABLE 3 - SERVICE AND DETECTED FAILURES OF ALL TYPES EXCEPT ENGINE BURN FAILURES ACCUMULATED FROM DATE ROLLED TO DECEMBER 31, 1963, PER 100 AVERAGE TRACK MILES, CONTROL COOLED RAIL ONLY, IN ALL ROLLINGS FROM ALL MILLS

Year Rolled	YEARS OF SERVICE									
	1	2	3	4	5	6	7	8	9	10
1953	0.8	2.0	4.0	9.2	15.6	22.5	30.6	30.9	47.6	60.0
1954	0.5	1.3	3.5	6.1	10.9	15.9	21.7	27.6	40.1	
1955	0.7	1.5	2.3	4.0	6.9	10.4	13.1	25.0		
1956	0.4	1.3	3.3	6.3	10.1	15.0	21.7			
1957	0.5	1.3	2.5	4.3	7.4	13.1				
1958	1.0	1.8	3.0	5.2	9.3					
1959	2.0	2.8	4.3	7.2						
1960	0.5	1.6	3.0							
1961	0.8	2.0								
1962	0.6									

TABLE 4 - TRACK MILES AND 1963 FAILURES, ALL TYPES, IN ROLLINGS 1953 TO 1962, INCL.
OPEN-HEARTH CONTROL-COOLED RAIL ONLY

ROAD	TRACK MILES BY MILL										1963 FAILURES	
	ALG	CARN	COLO	DOM	GARY	INLD	LACKA	STLTN	TENN	TOTAL	EBFs EXCL.	EBFs ONLY
AT&SF			1463		771	146				2380	25	
ACL								101	503	604	2	
B&O		162			417		48	423		1050	2	1
Ban Aroos								28		28		
B&LE		29								29	1	
B&M		3						34		37	1	
CP	2548			432			4			2984	361	
CARTIER				38	152					190	2	
C&O Sys.		4			623	393	216	94		1330	26	
C&EI					40	6				46		
C&NW					300	96	57			453	3	
CB&Q			457		512	85				1054		
CI&L					37	15				52		
CMStP&P					544	151				695	1	1
CRI&P			168		405	96				669	2	
C&S			308							308		
D&H								98		98	3	
D&RGW			273							273	46	
Erie-Lack		57			221	11	36	6		331		
GTW					146	39	18			203	3	
GN			424		399	122	147	22		1114	11	
IC Sys.					578	220			216	1014	5	
JLC								46		46		
KCS					105	17			12	134		
L&HR								8		8		
LV							142			142	3	
LI								37		37		
L&N					30				1127	1157	13	1
Me. Cent.							33	3		36		
MStP&SStM	11				156	115	10			292	2	
MKT			23		53	18				94		
MP Co.			411		535	53		9	90	1098	3	1
NYC Sys.					205	45	482			732	27	4
NYNH&H		69						121		190		
N&W		454						191		645	144	1
NP			301		268	43	86			698	7	
PRR		139			161	29		312		641	12	
P&LE		34			13					47	4	
QNS&L				279						279	71	
Reading								138		138		
RF&P								78		78		
STL&SF									654	654	2	
SAL								110	554	664		
SPCo Sys.			1934						85	2019	554	7
UP			1182		445	50				1677	382	1
W. Md.		57						155		212	2	
TOTAL	2559	1008	6944	749	7116	1750	1279	2014	3241	26660	1720	17

NOTE. The following railroads did not report and were omitted from this table: NYC&STL, B&OCT, C of G and SOUTHERN - No reason; FEC&Rutland - Because of strike, L&NE - Because of Bankruptcy.
The NYC Sys. includes the B&A, NYC Southern District (CCC&STL, P&E); NYC (New York District), NYC (Eastern District), NYC (Western District) and NYC (Northern District).
The DL&W merged with the Erie Railroad.
The NC&STL merged with the L&N Railroad.
The T&NO merged with the SP Railroad.
The Virginian merged with the N&W Railroad.
The T&P merged with the MP Railroad.

TABLE 5 - ACCUMULATED FAILURES AND FAILURES PER 100 TRACK MILES, IN ROLLING 1953 TO 1962. INCLUSIVE FROM DATE ROLLED TO DECEMBER 31, 1963, SERVICE AND DETECTED, BY MILL AND TYPE OF FAILURE

OH CONTROL-COOLED RAIL ONLY

MILL	ACCUMULATED FAILURES TO DEC. 31, 1963 (EXCL. EBFs)									ALL TYPES	TRACK MILES	TRACK MILE YEARS	FAILURES PER 100 TRACK MI. YEARS
	TF VER U of I	CF & DF	VSH	HSH	OTHER HEAD	BROKEN	WEB		BASE				
							IN JT.	OTHER					
ALGOMA	1	9	340	36	384	7	771	18	23	1589	2556	15592	10.19
CARNEGIE (ET)	1	891	2	18	35	5	17	5	3	977	1160	8245	11.85
COLORADO		1962	78	183	313	20	512	90	8	3166	7286	47501	6.67
DOMINION		49	68	81	68	22	263	12	15	578	749	5075	11.39
GARY		97	19	17	72	27	80	8	3	324	7193	48620	.67
INLAND	1	49	7	8	12	8	36	7	1	129	1773	13810	.93
LACKAWANNA	1	11	9	1	15	8	33	3	18	99	1285	8734	1.13
STEELTON	1	87	9	11	25	9	14	2	1	159	2129	14840	1.07
TENNESSEE		40	23	18	14	12	32	9		148	3239	22039	.67
ALL MILLS	5	3195	555	373	938	118	1758	154	72	7169	27370	184456	3.89
FAILURES PER 100 TRACK MILE YEARS	.003	1.73	.30	.20	.51	.06	.95	.08	.04	3.89			

Definition of symbols:

TF - Transverse Fissure
CF - Compound Fissure
DF - Detail Fracture

VSH - Vertical Split Head
HSH - Horizontal Split Head
EBF - Engine Burn Fracture

TABLE 5a - ACCUMULATED FAILURES AND FAILURES/PER 100 TRACK MILES, IN ROLLINGS 1953 TO 1962, INCLUSIVE FROM DATE ROLLED TO DECEMBER 31, 1963, SERVICE AND DETECTED, BY RAIL SECTION AND TYPE OF FAILURE

OH CONTROL-COOLED RAIL ONLY

RAIL SECTION	ACCUMULATED FAILURES TO DEC. 31, 1963 (EXCL. EBFs)									ALL TYPES	TRACK MILES	TRACK MILE YEARS	FAILURES PER 100 TRACK MI. YEARS
	TF VER U of I	CF & DF	VSH	HSH	OTHER HEAD	BROKEN	WEB		BASE				
							IN JT.	OTHER					
106 CF&I			1			1	1			3	30	167	1.80
112 TR		1	2	1	3				1	8	1065	8305	0.10
115 RE	1	182	32	45	47	19	74	11	3	414	7407	54967	0.75
119 CF&I		3	3	2	2	2	7	1	2	22	901	3992	0.55
127 NYC (Mod)		7	7	1	12	8	30	2	17	84	549	4263	1.97
129 TR		1		2	1		1			5	232	1742	0.29
132 RE	2	1054	65	116	105	49	103	32	3	1529	6297	43729	3.50
133 PS		1576	12	51	168	7	25	5	2	1846	1851	12563	14.69
136 RE		35	10	14	25	1	25	16	2	128	2280	10695	1.20
136 NYC							4			4	176	346	1.16
140 RE	1	13	1	3	15	6	8	1	3	51	1757	11517	0.44
155 PS		4	3	2	2		3			14	129	913	1.53
TOTAL	4	2876	136	237	380	93	281	68	33	4108	22674	153199	2.68
TOTAL PER 100 TRACK MILE YEARS	0.003	1.88	0.09	0.15	0.25	0.06	0.18	0.04	0.02	2.68			

TABLE 6 - ACCUMULATED FAILURES OF ALL TYPES FOR OH CONTROL COOLED RAIL, ONLY IN ROLLING 1953 - 1962, INCL., ACCUMULATED TO DECEMBER 31, 1963, SERVICE AND DETECTED, SEGREGATED BY ROADS AND MILLS.

ROADS	TF Ver U of I	CF & DF	VSH	HSH	Other Head	Broken	Web		Base	FAILURE TOTALS			
										EBFs Excl.		EBFs Only	
							In Jt.	Other		Accum. Total	1963	Accum. Total	1963
ALGOMA													
CP	1	9	340	36	384	5	771	18	23	1587	294	5	0
MStP&SStM	0	0	0	0		2	0	0	0	2	1	0	0
TOTAL	1	9	340	36	384	7	771	18	23	1589	295	5	0
CARNEGIE													
B&O	0	1	1	0	5	0	0	0	1	8	1	0	0
B&LE	0	0	0	0	0	1	0	0	0	1	1	0	0
B&M	0	0	0	0	0	0	1	0	0	1	1	0	0
Erie-Lack	0	0	0	0	0	0	2	1	0	3	0	0	0
NYNH&H	1	1	0	0	0	0	0	0	0	2	0	2	0
N&W	0	884	0	16	26	1	8	4	2	941	129	9	1
PRR	0	1	0	2	4	1	4	0	0	12	3	1	0
P&LE	0	3	0	0	0	1	1	0	0	5	3	0	0
W. Md.	0	1	1	0	0	1	1	0	0	4	2	0	0
TOTAL	1	891	2	18	35	5	17	5	3	977	140	12	1
COLORADO													
ATSF	0	14	4	0	3	2	22	8	3	56	15	2	0
CB&Q	0	1	0	0	2	0	0	0	0	3	0	0	0
CRI&P	0	1	0	1	0	0	0	0	0	2	0	0	0
C&S	0	0	1	1	1	0	0	0	0	3	0	26	0
D&RGW	0	102	4	25	4	2	5	0	0	142	46	0	0
GN	0	10	1	0	2	0	3	0	0	16	9	0	0
MP Lines	0	0	1	0	0	0	2	0	0	3	1	0	0
NP	0	3	9	1	10	0	5	0	0	28	4	3	0
SP Co. Sys.	0	339	48	107	144	15	458	76	3	1190	538	69	7
UP	0	1492	10	48	147	1	17	6	2	1723	351	4	0
TOTAL	0	1962	78	183	313	20	512	90	8	3166	964	104	7
DOMINION													
CP	0	3	36	2	29	0	261	0	13	344	67	0	0
QNS&L	0	46	32	79	39	22	2	12	2	234	71	0	0
TOTAL	0	49	68	81	68	22	263	12	15	578	138	0	0
GARY													
AT&SF	0	1	0	2	0	0	9	1	0	13	7	0	0
B&O	0	2	2	0	5	1	5	0	0	15	0	1	1
CARTIER	0	0	0	0	0	6	0	0	0	6	2	0	0
C&O Sys.	0	11	1	1	5	4	17	4	0	43	15	1	0
C&NW	0	0	1	0	0	0	0	0	0	1	1	0	0
CB&Q	0	1	1	1	0	0	1	0	1	5	0	0	0
CMStP&P	0	0	2	4	4	2	2	0	0	14	1	0	0
CRI&P	0	0	1	0	0	0	3	1	0	6	2	1	1
Erie-Lack	0	0	0	0	0	0	1	0	0	1	0	5	0
GTW	0	0	2	1	1	3	3	0	0	10	3	0	0
GN	0	10	1	2	14	0	2	0	0	29	1	0	0
IC Sys	0	2	2	0	5	2	7	1	1	20	4	1	0
L&N	0	0	0	0	0	0	1	0	0	1	0	0	0
MStP&SStM	0	0	0	2	0	0	2	0	1	5	0	0	0
MP Line	0	0	0	0	0	0	0	1	0	1	1	1	1
NYC Sys.	0	1	0	0	2	3	14	0	0	20	12	5	2
NP	0	0	3	1	3	2	5	0	0	14	2	4	0
PRR	0	2	1	1	0	3	6	0	0	13	2	4	0
P&LE	0	0	0	0	0	1	0	0	0	1	1	1	0
UP	0	67	2	2	33	0	2	0	0	106	28	2	1
TOTAL	0	97	19	17	72	27	80	8	3	324	82	25	6

TABLE 6 - CONTINUED

ROADS	TF Ver U of I	CF & DF	VSH	HSH	Other Head	Broken	Web In Jt.	Web Other	Base	FAILURE TOTALS EBFs Excl. Accum. Total	EBFs Excl. 1963	EBFs Only Accum. Total	EBFs Only 1963
INLAND													
AT&SF	0	0	2	0	0	0	2	2	0	6	3	0	0
C&O Sys.	1	8	1	1	1	1	15	2	0	30	7	0	0
C&NW	0	0	0	0	0	0	2	1	0	3	2	0	0
CB&Q	0	0	0	1	1	0	0	0	0	2	0	0	0
CMStP&P	0	0	1	0	2	0	1	0	0	4	0	0	0
CRI&P	0	0	0	1	0	0	0	0	0	1	0	0	0
GTW	0	0	0	0	0	0	3	0	0	3	0	0	0
GN	0	1	1	0	0	0	1	0	1	4	1	0	0
IC Sys.	0	0	1	2	4	1	4	1	0	13	1	0	0
MStP&SStM	0	1	0	1	0	5	3	0	0	10	1	0	0
MP Lines	0	0	0	0	0	0	2	0	0	2	1	0	0
NYC Sys.	0	0	0	0	0	0	1	0	0	1	0	0	0
NP	0	0	0	0	2	1	2	0	0	5	0	0	0
PRR	0	2	1	0	0	0	0	0	0	3	1	0	0
UP	0	37	0	2	2	0	0	1	0	12	3	0	0
TOTAL	1	49	7	8	12	8	36	7	1	129	20	0	0
LACKAWANNA													
CP	0	0	1	0	1	0	1	0	0	3	0	0	0
C&O Sys.	0	5	0	0	1	1	2	1	0	10	2	0	0
GTW	0	0	0	0	0	0	2	0	0	2	0	0	0
GN	0	0	0	0	2	0	0	0	0	2	0	0	0
LV	0	0	1	0	0	0	5	0	0	6	3	2	0
Me. Cent.	1	0	0	0	0	0	1	0	0	2	0	0	0
NYC Sys.	0	6	7	1	10	7	19	2	18	70	15	2	2
NP	0	0	0	0	1	0	3	0	0	4	1	0	0
TOTAL	1	11	9	1	15	8	33	3	18	99	21	4	2
STEELTON													
ACL	0	0	0	1	0	0	0	0	0	1	0	0	0
B&O	0	2	1	1	7	2	3	0	1	17	1	1	0
Ban Aroos	0	0	0	1	2	0	0	0	0	3	0	0	0
B&M	0	0	0	0	0	0	0	0	0	0	0	5	0
C&O Sys.	0	0	0	1	4	1	1	0	0	7	2	0	0
D&H	0	1	2	1	0	1	2	1	0	8	3	0	0
GN	0	0	1	1	0	0	0	0	0	2	0	0	0
LI	0	0	0	0	0	0	1	0	0	1	0	0	0
N&W	0	80	0	4	10	0	5	0	0	99	15	1	0
PRR	0	4	3	1	2	3	2	1	0	16	6	23	0
SAL	1	0	1	0	0	0	0	0	0	2	0	0	0
W. Md.	0	0	1	0	0	2	0	0	0	3	0	0	0
TOTAL	1	87	9	11	25	9	14	2	1	159	27	30	
TENNESSEE													
ACL	0	0	1	3	1	1	5	0	0	11	2	1	0
IC Sys.	0	9	3	4	7	0	1	0	0	21	0	2	0
L&N	0	18	12	6	6	2	22	7	0	73	13	8	1
MP Lines	0	0	1	0	0	0	0	0	0	1	0	1	0
STL&SF	0	0	2	2	0	6	1	0	0	11	2	0	0
SAL	0	2	3	2	0	3	0	0	0	10	0	0	0
SP Co. Sys.	0	11	1	1	0	0	3	2	0	21	16	0	0
TOTAL		40	23	18	14	12	32	9	0	148	33	12	1
ALL MILLS	5	3195	555	373	938	118	1760	154	72	7169	1720	192	17

TABLE 7
RAIL FAILURES IN THE WEB WITHIN THE JOINT BAR LIMITS FOUND IN 1963
ON RAIL OF 100 LB. AND ALL HEAVIER SECTIONS

	Rail Rolled Previous to 1937				Rail Rolled in 1937 and After				
	Detected Failures		Service Failures		Detected Failures		Service Failures		Joints Inspected with Defect Detecting Instruments
Railroad	Bolt Hole	Other	Bolt Hole	Other	Bolt Hole	Other	Bolt Hole	Other	
AT&SF	38	63	18	0	361	385	156	0	3,539,143
ACL	237	348	145	115	284	220	36	29	1,582,500
B&O	790	45	1606	107	60	12	52	21	-----
Ban & Aroos	1	1	1	1	5	0	4	0	90,996
B&LE	0	0	0	0	0	0	0	0	-----
B&M	138	45	94	16	17	16	9	12	683,820
CP	137	71	29	8	522	442	276	99	1.642.826
Cartier	0	0	0	0	0	0	0	0	-----
C&O (Sys.)	76	77	38	37	48	66	15	10	-----
C&EI	6	4	11	2	16	2	22	7	-----
C&NW	768	124	592	45	137	90	175	78	1,673,133
CB&Q	80	6	170	14	8	0	360	55	812,471
CI&L	62	0	21	15	15	0	2	2	74 000
CMSt P&P	263	6	122	0	40	3	38	0	288,448
CRI&P	250	309	101	120	20	8	122	134	-----
C&S	0	0	0	0	0	0	3	0	-----
D&H	69	5	9	1	27	18	2	0	298,000
D&RGW	37	51	5	2	20	97	5	3	282.150
Erie-Lack	178	95	29	8	45	95	17	4	1,017,171
GTW	31	0	66	26	52	0	17	3	246,671
GN	13	10	4	0	121	242	52	0	153.810
IC	17	9	18	6	46	50	72	33	179,236
JCL	67	28	7	18	11	6	0	0	174,223
KCS	3	1	0	3	4	3	0	2	-----
L&HR	15	3	37	0	12	0	14	0	9,600
LV	5	2	46	9	0	0	7	3	38,900
LI	142	92	50	17	5	5	1	0	-----
L&N	445	229	212	0	288	51	111	0	70.000
Me. Cent.	1	0	16	0	3	0	2	0	-----
MSt P&SSt M	76	0	51	0	13	0	32	0	1,952
MKT	1083	462	6	0	34	13	10	2	-----
MP Lines	122	133	341	39	366	12	100	17	-----
NYC (Sys.)	953	454	95	25	1214	1052	184	83	-----
NYNH&H	8	8	68	15	173	300	3	6	-----
N&W	5	3	0	0	5	3	7	2	-----
NP	73	16	132	45	209	363	309	350	534.551
PRR	1406	234	2339	283	522	189	374	159	1.354.090
P&LE	1	0	0	0	17	4	1	0	160.381
Reading	0	0	0	0	0	0	0	0	-----
RF&P	0	0	0	0	5	7	0	2	-----
StL-SF	22	51	4	49	75	161	11	90	43,919
SAL	18	3	16	3	19	14	46	10	-----
SP	12	9	17	23	726	1309	316	367	-----
UP	234	140	2	0	267	91	11	6	500,000
W. Md.	4	0	0	0	52	39	8	1	-----
Totals	7886	3137	6521	1052	5864	5368	2982	1590	15,451,991

TABLE 8 - ACCUMULATED TRANSVERSE FISSURE FAILURES IN CONTROL COOLED RAIL AS VERIFIED BY LABORATORY INVESTIGATION, MILL AND YEAR ROLLED TO OCTOBER 1, 1964

Mills	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	Total
Algoma					2b	2a	2b	1b	1a	1a		1a 2b	1a 1b	1b	1a 12b	7b	1b		1a			37
Carnegie (ET)			1c		1a				2c							1c	2c					7
Colorado	*				1c		1c															2
Dominion						1b																1
Gary	1b	7b	4b	1b											1b							14
Inland	1a		3a		3a	3a	8a		1a	7a 1b	1a	2a		1a			1a	4a		2a	1a	39
Lackawanna								6a	2a	8a			3a	1a	1a	1a						22
Steelton	5a	22a	13a	11a	11a	15a 1c	6a	16a 1c	8a	1a	2a	3a	2a	3a	2a	5a	3a	4a	1a			135
Tennessee		1b					1c		2c								1c					5
TOTAL	7	30	21	12	18	22	18	24	16	18	3	8	7	6	17	14	8	8	2	2	1	262

Note: (a) TRANSVERSE FISSURE from hot torn steel. (b) TRANSVERSE FISSURE from shatter cracks due to improper cooling. (c) TRANSVERSE FISSURE from inclusion. Summary - 46 T.F.'s from shatter cracks, 14 T.F.'s from inclusions, 202 T.F.'s from hot torn steel.

*No CC rail rolled.

TABLE 9

WELDED ENGINE BURNS AND FAILURES

Railroad	Engine Burns Welded Prior To 1963	Burns Welded In 1963	Failed Welded Engine Burns During 1963
AT&SF	115,274	2,397	0
B&O	5,984	Did not Report	
C&O	49,382	2,290	0
C&NW	18,185	2,168	0
D&H	8,143	41	2
EJ&E	65,954	3,129	0
IC	51,982	7,862	1
PRR	375,994	31,969	2
RF&P	17,941	0	0
STL-SF	4,008	275	1
SAL	26,765	2,974	0
Southern (West Div.)	145,591	Did not Report	
SP	2,109	Discontinued Keeping This Information	
Total	887,312	53,105	6

Report on Assignment 6

Joint Bars: Design, Specifications, Service Tests Including Insulated Joints and Compromise Joints

Embert Osland (chairman, subcommittee), G. V. Begany, Jr., H. B. Berkshire, J. A. Bunjer, R. E. Catlett, Jr., C. O. Conatser, P. K. Cruckshank, C. J. Henry, O. E. Fort, T. B. Hutcheson, H. W. Jenkins, K. K. Kessler, Hugues Marquis, Ray McBrian, C. E. Morgan, R. H. Patterson, J. G. Roney, D. H. Shoemaker, W. A. Smith, A. P. Talbot, D. J. White, H. M. Williamson.

Final inspection and measurements were made of the service test installations of joint bars for 115-lb and 132-lb rail on the Chicago & North Western and the Santa Fe railways by the AAR Engineering Division research staff.

The installations were made in 1948 for the purpose of comparing under actual service conditions the drilling pattern (6—6—7⅛—6—6 in) adopted for 115-lb and 132-lb rail, with the old AREA pattern for 112-lb and 131-lb rail sections (6½—6½—5⅛—6½—6½ in), using AREA-design joint bars in both cases. The test also included rail drilling for 4-hole joint bars punched 9—9⅛—9.

The test on the Santa Fe was extended to include the heavier design of the Rail Joint Company's short toe bars, K–42, and the long toe bars, K–94.

Progress reports on the investigation are published in Proceedings of the AREA, Vol. 50, page 515; Vol. 51, page 570; Vol. 52, page 634; Vol. 53, page 868; Vol. 54, page 1212; Vol. 55, page 803; Vol. 56, page 929; Vol. 58, page 995, Vol. 60, page 905 and Vol. 62, page 615.

AAR Research Report No. ER-50* covers the final inspection and report.

SUMMARY

1. All designs of joint bars have been adequate throughout the service period of 16 years.

2. Four bolts in 36-in joints with 9—9⅛—9 in spacing are adequate to hold the rail, but do not provide sufficient rail end support; hence, additional batter and droop of the rail ends occur compared with 6-bolt bars.

3. There appears to be little difference in the performance of the current AREA bolt-hole spacing of 6—6—7½——6—6 in compared with the former 6½—6½—5⅛—6½—6½-in spacing, where such a comparison can be made in the Santa Fe test.

Report on Assignment 7

Metallurgical Effect of Rail Cropping Methods

V. E. Hall (chairman, subcommittee), W. D. Almy, G. V. Begany, Jr., J. A. Bunjer, R. M. Brown, J. T. Collinson, P. K. Cruckshank, O. E. Fort, C. E. R. Haight, T. B. Hutcheson, J. C. Jacobs, H. W. Jenkins, Hugues Marquis, C. E. Morgan, J. S. Parsons, G. C. Payne, G. L. P. Plow, D. H. Shoemaker, E. H. Waring, C. E. Weller, D. J. White.

Your committee presents, as Appendix 7-a, AAR Research Department Report No. ER-47. The AAR is also investigating a gasoline-oxygen torch method of rail cropping which shows some promise of producing economical cuts without harmful heat effects.

Appendix 7-a

Rail Cropping by the Wet Abrasive Wheel Method at the Illinois Central Railroad Rail Welding Plant

Cropping relay rail and rail-end preparation, particularly for butt welding by the oxyacetylene pressure process, are subjects of interest to the railroad industry. The AAR Research Department undertook an investigation of this matter and issued a report (Engineering Division Report No. ER-42) on the dry abrasive wheel method of cropping rail in the field. This report also appears on pages 852-864 of Bulletin 586, June-July 1964.

Since the Illinois Central desired to butt weld quantities of cropped relay rail, C. E. Weller, engineer maintenance of way of the road, requested an investigation of wet abrasive wheel methods for cropping rail. This led to the installation of a production dual-head wet abrasive wheel rail cropping machine at the IC welding plant at Centralia, Ill.

In order to have a complete record of this new method of preparing the surfaces of the rails for butt welding by the oxyacetylene pressure process, Mr. Weller also requested rolling-load, slow-bend and drop tests. These were made at the AAR Research Center by Kurt Kannowski, former metallurgical engineer, under the direction of G. M. Magee, director of engineering research.

---

* Copies of this report may be obtained from G. M. Magee, director of enginering research, Association of American Railroads, 3140 S. Federal St., Chicago, Ill. 60616

The IC wet abrasive wheel rail cropping machine is shown in Fig. 1 with the dual cutting heads indicated by arrows. The machine was supplied by the American Railroad Supply Company. The speed of the abrasive wheel is constant at approximately 1100 rpm. Fig. 2 shows the wheel approaching the rail. The wheel is 26 in. in diameter and is marked ARSCO 105, RC32B. The relay rail is positioned for cropping by means of stops, as shown on Fig. 3.

In preparing the faces of new rail for welding, another set of stops is used which permits cutting off a slice of rail ½ in thick. The machine consistently produces square ends on both new and relay rail, as shown on Fig. 6. Such performance depends a great deal on the condition of the abrasive wheel which must be flat before being used. It is recommended that the wheels be stored on a flat surface, such as a marble plate, at a minimum temperature of 75 F.

Cutting speed is regulated by the air-hydraulic feed of the wheel into the rail. Cuts can be made in 11 sec or less, producing clean welding surfaces. However, this speed shortened the wheel life considerably. The effect of reducing the speed on lengthening wheel life and on the appearance of the welding surface was studied. After slowing down the feed so as to make a cut in 2 min, it was observed that the welding surface had some dark smudges from the binder of the abrasive in the wheel. This smudge could not be dissolved with solvent and was also difficult to remove with wire brushing. In order to investigate the effect of this smudge, four butt welds were made for rolling-load and slow-bend tests. The results are shown in Tables 1 and 2. The speed of cutting was finally adjusted to 40–45 sec, which produces a clean welding surface, as shown on Figs. 5, 7 and 8. It was observed that moving two rails into the machine, and positioning, clamping, cutting and removing them, consumed 2½ min on the average for each rail. At the above cutting rate, 40 cuts were made at a wheel cost of 21.2 cents per cut. This reduces the diameter of the wheel from 26 to 20 in and ends its useful life. Although the 20-in diameter wheel is still usable, it cannot be used in this operation. It is reported that ordinarily 25 to 45 cuts are made with a wheel, bringing the average to 38 cuts. However in studying production record sheets for two 10-hr working days and two 8-hr working days, an average of 46 cuts per wheel was determined, reducing the wheel cost of a cut to 18.5 cents. This production rate produces enough cropped rail in an 8-hr day for a 10-hr welding operation which produces 165 to 196 welds, with an average of 180 welds.

Using this procedure for preparing the welding surfaces, six more butt welded rail joints were produced for rolling-load, slow-bend and drop tests. The results are shown in Tables 1 and 2. The welding surfaces are shown on Figs. 5, 7 and 8. It can be noted that the surfaces are relatively smooth compared to hack-saw-cut surfaces. The surfaces were also free of smudges or burned areas. One laborer, as shown on Fig. 9, is required to remove the burrs and inspect the rails for both welding units. The rail welding surface, as shown on Fig. 10, is free of any undesirable surface effects and was prepared by deburring only.

The rolling-load tests of four butt-welded rail joints representing two welding-surface conditions (smooth-and-clean, smooth-and-smudged) were made at the AAR Research Center, using a 12-in-stroke machine. The results are given in Table 1. A 48,000-lb wheel load was applied to each joint with the weld placed 2 in from the support on the cantilever end of the rail. Since the wheel path extends 10 in beyond the weld, the weld is subjected to a bending moment of 480,000 in-lb. With this procedure, 2,000,000 load applications or cycles without failure is considered a run out. As shown in Table 1, all four joints ran out at 2,000,000 cycles without failure.

The slow-bend tests of four welded joints, also representing the two welding-surface conditions, were also made at the AAR Research Center. The results are given in Table 2. Each test was made with the rail head up on supports 48 in apart. The load was applied at two points, one on each side of and 6 in from the midpoint of the span, which would be the weld. Thus, the applied bending moment between these load points in inch-pounds was nine times the load.

The drop tests on two of the rail joints with clean welding surfaces were made at the AAR Research Center. In this test a standard rail drop-testing machine is used in which a 2000-lb tup is dropped from various heights depending on the rail section. In this case, using a 115 RE rail, it was dropped 20 ft on the center of the rail or weld which was head up. Both of the rail joints failed on the first blow, one of them breaking outside of the weld.

The results of one of the drop tests and two slow-bend tests were affected by a weld defect—a partially fused area in the base. This weld defect is caused by uneven heat distribution on the rail cross section. In this case, the base was at a higher state of plasticity than the head and did not forge during the upset. This condition was corrected after the tests were made.

It can be noted from the test results that butt-welded rail joints produced with weld surfaces representing both the smooth-and-clean condition and the smooth-and-smudged condition, performed excellently under the rolling-load tests. The best results under the slow-bend test was obtained from a rail joint that had a smudged weld surface. It is to be understood that this type of welding-surface condition is not recommended. It was investigated because it was the only observable variation from the recommended clean welding surface that developed in this cropping operation.

The observations and test results in this report indicate that the wet abrasive steel cutting method for rail produces the square rail ends and clean welding surfaces necessary for the oxyacetylene pressure butt-welding process.

TABLE 1—ROLLING-LOAD TEST RESULTS OF OXYACETYLENE PRESSURE BUTT-WELDED RAIL JOINTS WITH ABRASIVE-WHEEL-CUT WELDING SURFACES

Spec. No.	*Surface Condition of Welding Surface*	*Rail Section*	*Wheel Load, Lb*	*No. Cycles*	*Remarks*
1A	Smooth and Clean	115 RE	48,000	2,000,000	No Failure
1B	Smooth and Clean	115 RE	48,000	2,000,000	No Failure
2A	Smooth and Light Smudge	115 RE	48,000	2,000,000	No Failure
2B	Smooth and Medium Smudge	115 RE	48,000	2,000,000	No Failure

TABLE 2—SLOW-BEND TEST RESULTS OF OXYACETYLENE PRESSURE BUTT-WELDED RAIL JOINTS WITH ABRASIVE-WHEEL-CUT WELDING SURFACES

Spec. No.	*Surface Condition of Welding Surface*	*Head Up or Down*	*Max. Load, Lb*	*Max. Defl., In*	*Energy to Fracture, Ft-Lb*	*Remarks*
1D	Smooth and Clean	Up	288,000	1.2	20,400	Broke from base—no fusion.
1F	Smooth and Clean	Up	293,000	1.1	19,600	Broke from base—no fusion.
2C	Smooth and Light Smudge	Up	236,000	0.6	7,900	Good structure—broke from base.
2D	Smooth and Medium Smudge	Up	340,000	2.2	47,000	Broke outside of weld.

All specimens were tested on supports 48 in apart and loaded at two places, one on each side of and 6 in from mid-point of the span.

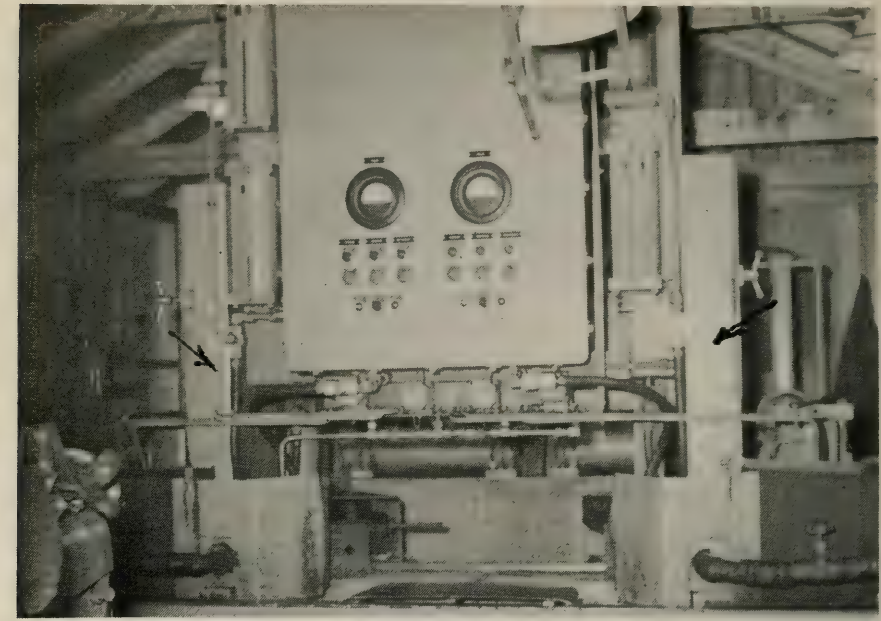


Fig. 1—Wet-abrasive-wheel rail-cropping machine at the Illinois Central rail-welding plant, Centralia, Ill.

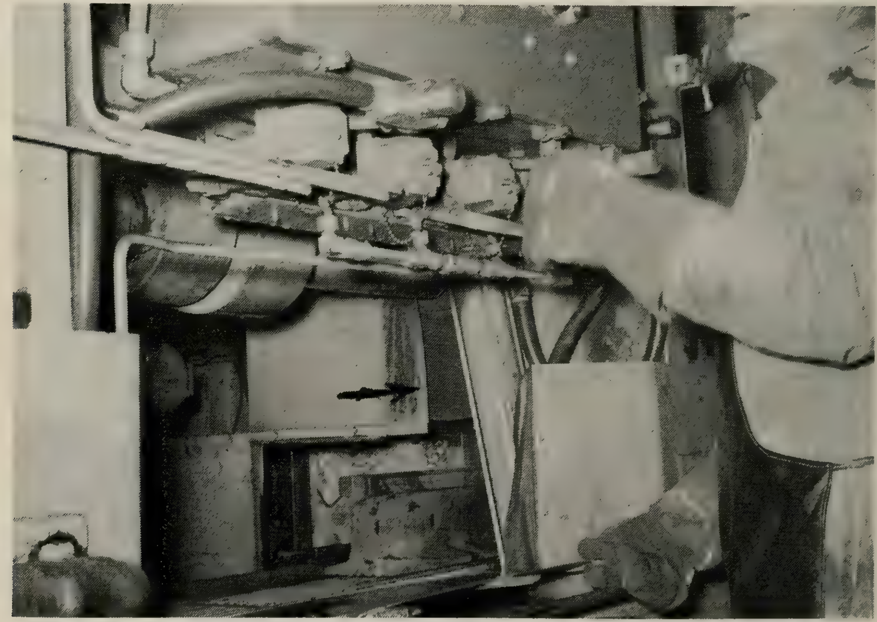


Fig. 2—Abasive wheel (arrow) approaching rail to be cropped.

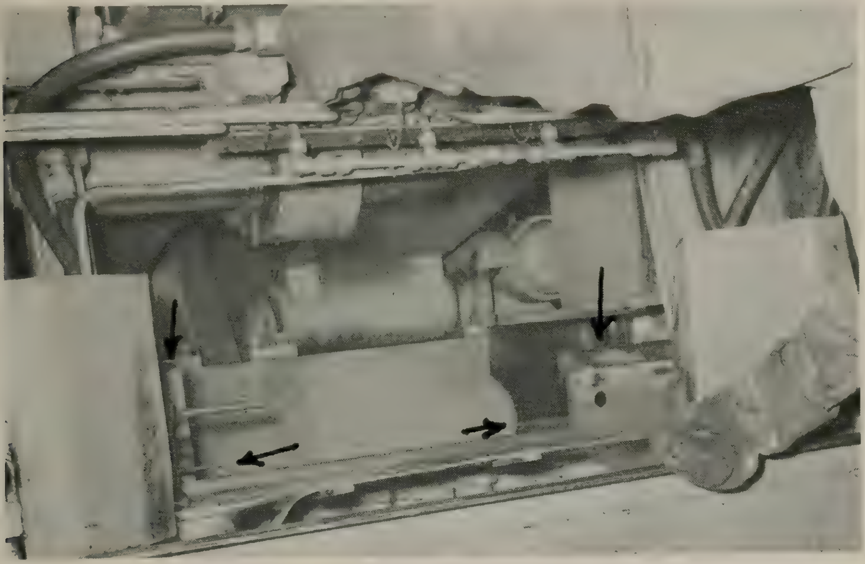


Fig. 3—Rails in position for cropping (indicated by the vertical arrows). The horizontal arrows point to the stops for positioning the rails.

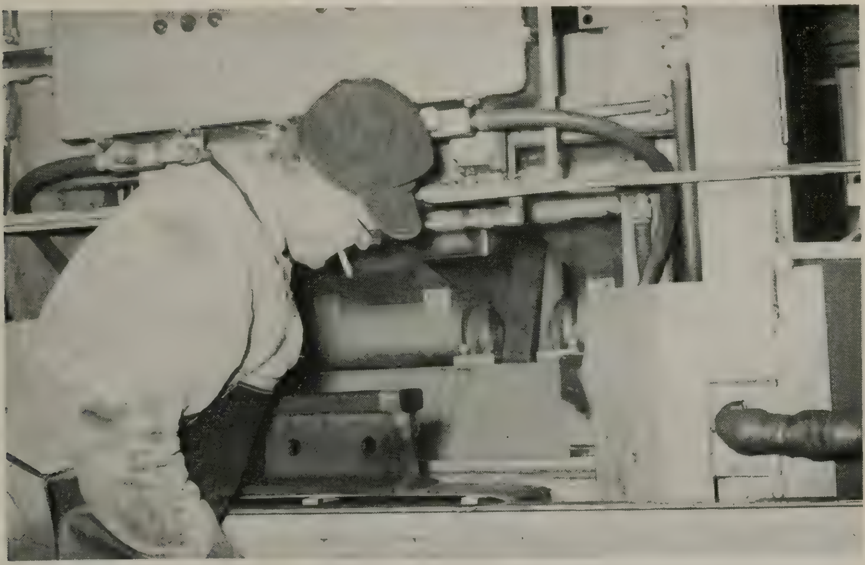


Fig. 4—Cropped rail end.

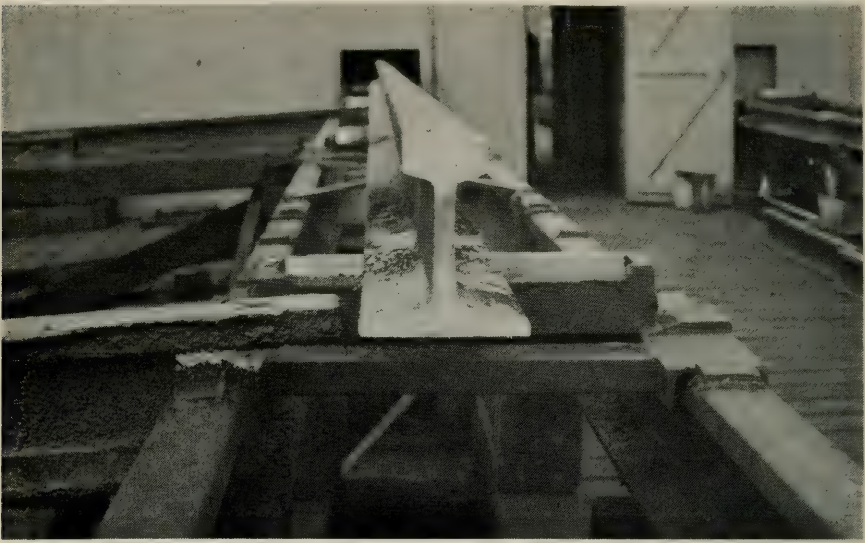


Fig. 5—Condition of rail end after being cropped.

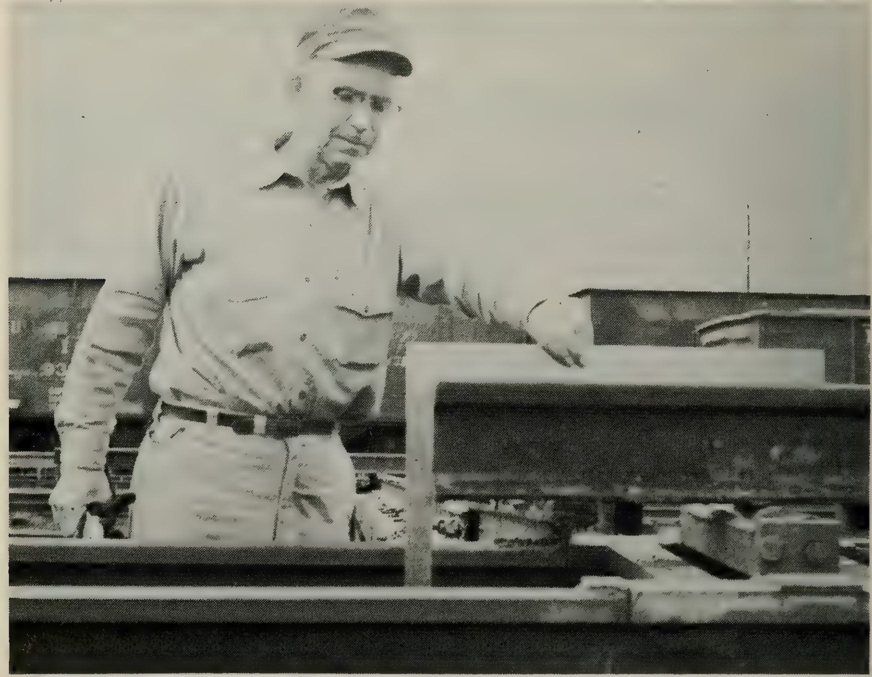


Fig. 6—The machine consistently produces square ends on both new and relay rail.

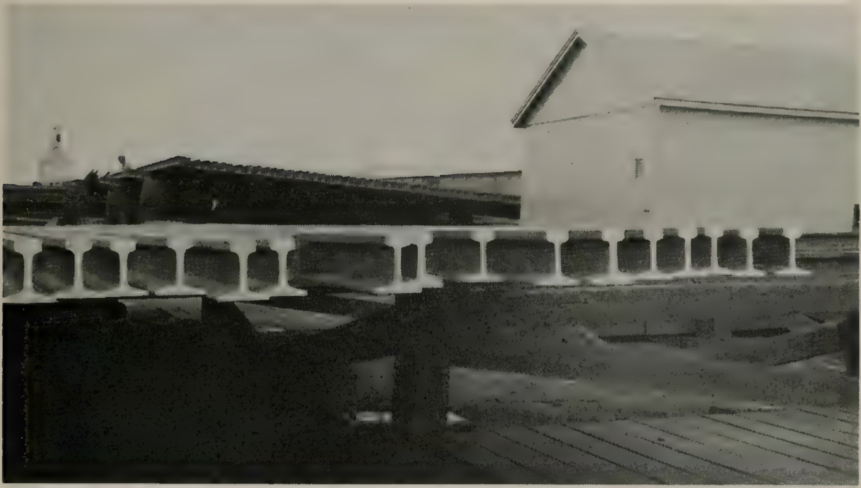


Fig. 7—General condition of rail-end welding surfaces after cropping.

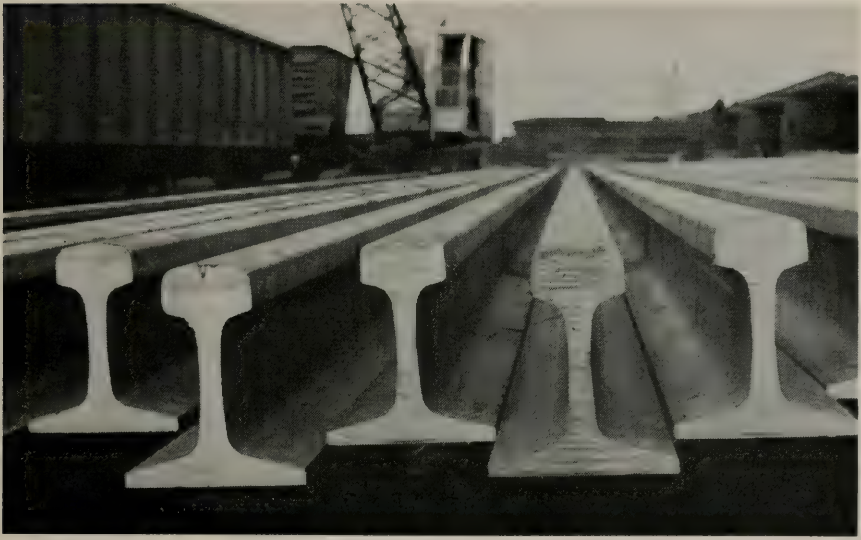


Fig. 8—Another view of the welding surfaces after cropping the rails.

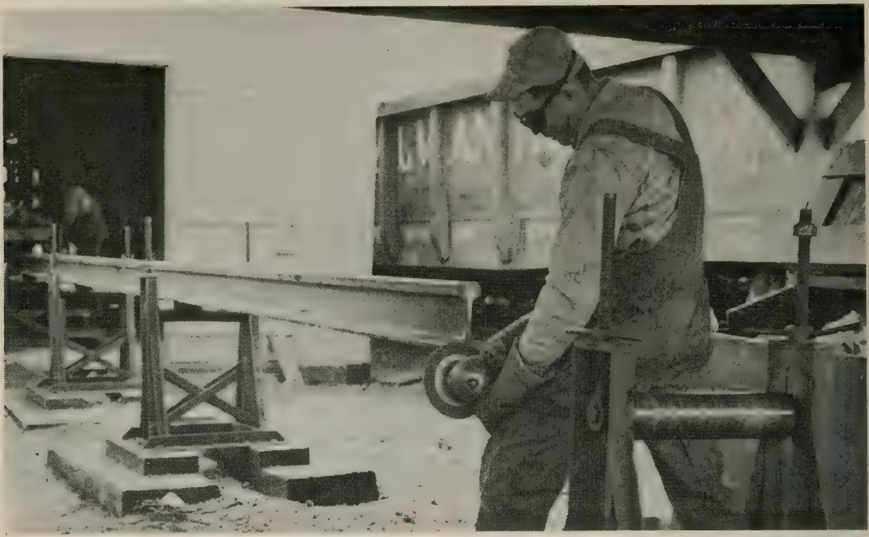


Fig. 9—Before entering the welding plant, burrs are removed from the edges of the rail cross section.

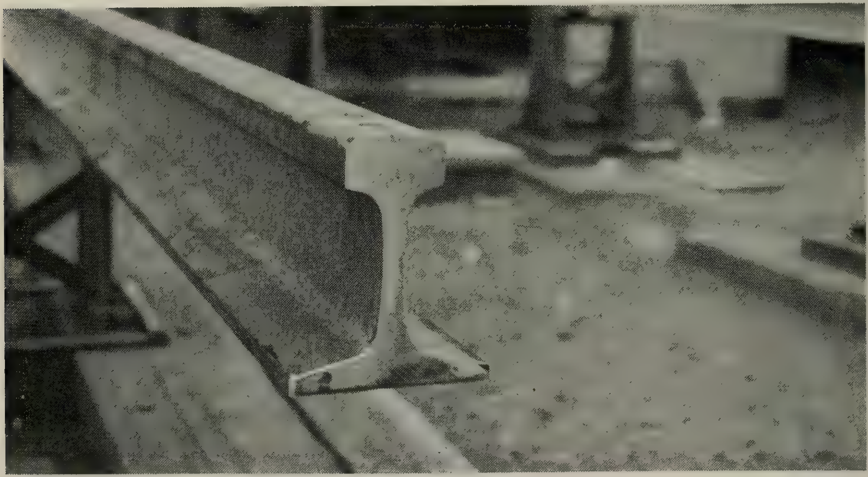


Fig. 10—Final condition of a rail end before entering the welding plant.

Report on Assignment 8

Causes of Shelly Spots and Head Checks in Rail: Methods for Their Prevention

C. F. Parvin (chairman, subcommittee), W. D. Almy, B. Bristow, J. A. Bunjer, T. F. Burris, J. B. Clark, C. J. Code, C. A. Colpitts, C. O. Conatser, P. K. Cruckshank, W. J. Cruse, F. L. Etchison, D. T. Faries, V. E. Hall, C. J. Henry, C. C. Herrick, T. B. Hutcheson, Hugues Marquis, Ray McBrian, B. R. Meyers, C. E. Morgan, G. L. P. Plow, R. B. Rhode, E. H. Waring, W. L. Young.

This is a progress report, presented as information.

During the past year work on this assignment has been conducted at the AAR Research Center by Kurt Kannowski, formerly metallurgical engineer, under the direction of G. M. Magee, director of engineering research.

The assignment is being carried on in two phases: One is the inspection of heat-treated and alloy rail service test installations on curves with shelly histories; the other is the laboratory investigations of shelly rail involving rolling-load and slow-bend tests.

The usual service test inspections were made of the fully heat-treated and alloy rail installations to corroborate the observations of previous years. Of interest this year is the service test installation of induction-hardened rail on the Great Northern Railway and on the Norfolk & Western Railway. Of further interest is the test installation to compare high-carbon rail with blue-end rail on the Pennsylvania Railroad. The results of the latest inspection are presented below in Appendix 8–a.

The laboratory investigations cover the new developments in induction and flame hardening of rails to increase their resistance to shelling. Appendix 8–b below is a report on the laboratory investigation.

Appendix 8–a

Results of Inspections of Heat-Treated and Alloy Rail Service Test Installations on Curves with Shelly Histories—1964

CHESAPEAKE & OHIO RAILWAY SERVICE TEST OF 132-LB FULLY HEAT-TREATED RAILS

The 12 fully heat-treated and 12 non-heat-treated, end-hardened rails which were laid in the high and low sides of the 3-deg 6-min curve at Martha, W. Va., on May 2, 1949, were inspected on May 19, 1964.

On June 12, 1961, after more than 12 years of service and after carrying approximately 325,000,000 gross tons of traffic, the test rails were transposed. The rails from the high side of the curve were laid in the low side while the low side rails were turned end for end and laid in the high side of the curve. The low-side rails were turned so as to use the corner of the rail head showing the least fin for the new gage side.

At the time of an inspection on May 22, 1962, the rails had carried approximately 25,000,000 gross tons in their transposed position and appeared to be performing normally. By the time of the last inspection the rails had carried approximately 72,040,000 gross tons since transposition for a total of approximately 397,040,000 gross tons since May 1949.

Only one test rail has been removed from service. Fully heat-treated rail 87581–C14 was badly marked by engine wheel burns 7 ft from the receiving end while it was in the low side of the curve. It has been removed from its high-side transposed position within the last year.

No gage corner developments, such as flaking and shells, were noted in any of the test rails. Wheel contact on the gage corner of the high-side fully heat-treated rails appears quite normal. However, the heavy fin of plastically deformed head metal on the non-heat-treated rails which formed while the rails were in the low side of the curve has not cut away very fast, and in some cases appears to be increasing.

Several low-side rails show areas of mild flow across the head of the rail at locations opposite shells, which developed while the rails were in the high side of the curve prior to transposition.

Generally speaking, the rails appear in good condition considering the tonnage already carried and can be expected to give considerable additional service.

GREAT NORTHERN RAILWAY SERVICE TESTS

115 RE High-Silicon Rail

This service test was installed to investigate the properties of high-silicon rail in resisting abrasion and shelling. Two locations, each with two comparable curves, were selected. High-silicon rails were laid on both the high side and the low side on one of the curves at each location and standard control-cooled rails on the other curve. These installations are described extensively in Proceedings, Vol. 58, page 1028.

During an inspection in August 1964 of Cascade Division curves 48 and 52, which had carried 120 million gross tons of traffic, it was noted that the high-silicon rail on the high side of the curves had less wear than comparable standard carbon rail and that the high-silicon low rail had less head flow than the comparable standard carbon rail. A small shell was noted on high-silicon rail 1162 B17, whereas the standard control-cooled rail had worn enough to prevent shelling. The curve on which these rails were located was not lubricated.

The control-cooled rail on curves 705 and 710 of the Cascade Division after 145 million gross tons of traffic had passed over it again had more curve wear on the high side compared to the high-silicon rail. It was also noted that the low-side control-cooled rail had more head flow compared with the high-silicon rail.

On curve 705, consisting of standard control-cooled rail, the following defects were noted, starting at the east end of the curve:

Rail	*Defects*
3142–B–22	2 light and 2 medium shells
3142–E–21	3 light shells
3142–B–13	medium flaking
3142–F–12	medium flaking
12143–C–15	heavy shelling throughout rail
12143–B–16	light shelling throughout rail and 5 heavy rails
3142–B–12	medium flaking
3142–E–4	medium flaking and light shelling throughout rail
15144–B–18	7 light shells

On curve 710, consisting of high-silicon rail, the following defects were noted, starting at the west end of the curve:

Rail	*Defects*
16191–E–1	3 heavy shells midway in rail
16191–E–20	1 heavy shell midway in rail
16191–D–16	3 small and 2 heavy shells
16191–E–11	6 small and 1 large shell midway on the rail
16191–D–14	2 medium shells
16191–C–15	2 medium shells and flaking
16191–C–14	2 light shells
16191–C–13	1 heavy and 6 light shells
16191–C–21	1 heavy and 4 light shells
16191–B–21	3 light shells
16191–E–5	1 heavy and 5 light shells
16191–F–9	9 light shells
16191–D–2	6 light shells
16191–D–12	8 heavy and 4 light shells

Rail 16191–E–12 was removed from this curve on February 3, 1964, because of a detected progressive vertical fracture from shelling. The gage at the time of inspection on curve 705 was 56⅜ to 56⅝ in and on curve 710 it was 56⅛ to 56⅞ in. Both curves were well lubricated.

Service Tests of Curvemaster and Fully Heat-Treated Rails

An inspection was made of the comparative service test of Curvemaster rail and fully heat-treated rail on September 22 and 23, 1964, on the Great Northern Railroad. The test rails were installed on curves 125, 133 and 136 during the week of August 3, 1964.

These curves are on the westbound track between Nimrod and Blacktail, Mont., M.P. 1165 to M.P. 1160, about 70 miles from Cutbank, Mont. The curves are on a descending grade of 1.8 percent. The speeds of the trains over these curves are 40 mph for passenger trains and 25 mph for freight trains. A better than normal ballast and tie condition was observed. The ballast consists of crushed granite. The rails are of 115 RE section rolled in 1964.

Curve 125 laid with Curvemaster rail is of 6 deg 35 min curvature with a superelevation of 4½ in. The rail is Illinois from heat 840875. The installation consists of nine 78-ft rails on the high side and nine 78-ft rails on the low side of the curve. The 78-ft rails were produced by flash butt welding. Contours were taken in the center of the receiving 39-ft rail of each 78-ft rail. A contour was also taken 1 in from the center of the weld on the receiving end of the 39-ft rail. The gage was 56⅜ to 56⅞ in.

Curve 133 laid with fully heat-treated rail is of 7 deg 25 min curvature with a superelevation of 6 in. The rail is Steelton from heats 286155 and 250145. The installation consists of nine 78-ft rails on the high side and nine 78-ft rails on the low side of the curve. The 78-ft rails were produced by flash butt welding. Contours were taken in the center of the weld on the receiving end of the 39-ft rail. The gage was 56½ to 56⅞ in.

Curve 136 laid with fully heat-treated rail is of 6 deg 27 min curvature with a 3½-in superelevation. The rail is Steelton from heats 290145, 288150 and 289127. The installation consists of four 78-ft rails on the high side and four 78-ft rails on the low side of the curve. The 78-ft rail was produced by flash butt welding. The same procedure in taking contours was followed as on curves 125 and 133. The gage was 56¼ to 56⅝ in.

Curve 136 laid with fully heat-treated rail is of a 6-deg 17-min curvature with a 3½-in superelevation. The Steelton rail is from six different heats. The installation consists of four 78-ft rails on the high side and four 78-ft rails on the low side of the curve. The 78-ft rail was produced by flash butt welding. The gage was 56¼ to 56⅞ in.

PENNSYLVANIA RAILROAD SERVICE TESTS

140 RE High-Silicon Rail

This test installation of high-silicon 140 RE rail is located in the Pennsylvania Railroad Altoona District No. 4 track, east of Mifflin, Pa., between M.P. 152 and M.P. 153 + 2530. The test rails are installed in the 5-deg Mifflin reverse curve, in the 3-deg 15-min Stone House curve, and in the 2-deg Casners curve in alternating groups of three high-silicon and three standard high-carbon rails on both the high and low sides of the curves.

This installation is described in AREA Proceedings, Vol. 58, page 962 and Vol. 60, pages 872 and 873.

At the time of the June 9, 1964, inspection 243 million gross tons had passed over the rail. It was noted that the high-silicon rail had no black spots or shelling. A general condition of light to medium flaking was observed. The curve wear was heavy on the Mifflin reverse curve and medium on the others. The standard carbon rail showed a higher degree of wear and had seven rails with black spots and shelling compared to four rails in 1962. The condition of the old shells were the same on Heat 07H294–F–5 as in 1962 on the center of Stone House curve. The shell on B–1 in the same curve is more prominent. Rail C–4 and C–6 on Casners curve each have an additional shell. On rail B–6 the middle black spot of the three observed in 1962 has been worn away but the crack is still present. New shells were observed last year on rails of Heats 16H302–D–10, 07H394–B–19, and 07H294–E–2 in the middle of Casners curve.

The low-rail condition of light to medium head flow and crushing was the same on both the high-silicon and standard carbon rail. Because of the excessive wear on the 5-deg Mifflin reverse curve, the rail was replaced.

The observations of the 1964 inspection indicate that at 283 million gross tons the high-silicon rail shows a greater resistance to shelling than the standard carbon rail.

Service Test of 155 PS High-Silicon Rails

On June 9, 1964, an inspection was made of the 155 PS high-silicon rails produced at Steelton in September 1953, and installed by the PRR October 5–9, 1963, in the No. 1, eastbound track in the 2-deg 37-min Bixler Curve east of Lewistown, Pa., at M.P. 164.

The high-silicon rails made from heat 86N594 were laid in groups of five rails of standard analysis (blue ends) starting in the tangent just west of the curve. All the rails were end hardened at Steelton. The ladle analyses of the heats in the test follows:

		C	*Mn*	*P*	*S*	*Si*
High silicon	86N495	0.79	0.72	0.01	0.034	0.59
High carbon	87N466	0.78	0.86	0.02	0.028	0.14
High carbon	90N479	0.78	0.86	0.02	0.026	0.15

On January 19–20, 1959, the test rails east of joints No. 406 (low side) and No. 407 (high side) were transposed. The rails west of joints 406 and 407 are in the entering spiral and tangent before the curve and have not shown any evidence of flaking or crushing.

At the time of the 1964 inspection the total gross tonnage over the test rails since installation was 341,800,000, of which 184,000,000 gross tons had accumulated prior to transposition, and 157,800,000 gross tons since.

All the rails at full elevation in the curve showed flaking to some degree throughout their length, with a few areas showing rather heavy flaking. By comparing the current conditions with photographs at the time of the 1963 inspection, it was noted that the degree of flaking varied, in a few cases being lighter than last year, but in perhaps more instances, appearing heavier this year. This is just the reverse of the situation noted when the photographs of 1962 were compared with the conditions noted in 1963. Generally, it still appears that the size and depth of the flaked areas in the high-silicon rails are less than in the standard analysis rails. An increase in the amount of curve wear was noted.

Areas of mild crushing which occurred while the rails were in the low side of the curve may still be noted in several of the standard-analysis high-side rails. The gage was checked at several points and was found to be up to 57 in (½ in wide). There was no noticeable lubrication on the high rails throughout the curve.

It should be noted that no shelly spots have developed in either the high-silicon or standard analysis rails. Consequently, the only difference between the two types of rail would lie in the wear pattern.

Service Test of 140 RE 0.79 Percent/0.92 Percent Carbon Rails

On June 10, 1964, the initial joint inspection was made of the special high-carbon and comparative standard-analysis 140 RE rails installed by the PRR May 22, 1963, in the No. 3 eastbound freight track at York Haven, Pa.

Sixty-eight special high-carbon rails and 69 rails of standard analysis were laid primarily in alternate groups of three in both the north and south sides, starting on the tangent at M.P. 68 + 2110 ft and extending west through a 4-deg 45-min curve, a short tangent, and a compound 4-deg 8-min and 2-deg 6-min curve to M.P. 68 + 4439 ft.

The 68 high-carbon rails were rolled from Steelton heat 85068 in February 1963, and were end hardened and stamped CHH ahead of the heat number. The ladle analysis for the heat follows:

	C	*Mn*	*P*	*S*	*Si*
Percent	0.89	0.85	0.014	0.053	0.22

The 69 comparative standard-analysis rails (50 Illinois, 19 Steelton), all "A" rails except for two short rails, were rolled from 22 different heats (17 Illinois, 5 Steelton). These were also end hardened and stamped CH ahead of the heat numbers.

To the date of the 1964 inspection, the test rails had carried approximately 38 million gross tons of traffic. The wear pattern, flow of the head metal, and flange cutting appeared very similar in both the high carbon and standard rails. However, light flaking was noted in one standard rail in the high side of the 4-deg 45-min curve, and in four or five of the standard rails in the high side of the 4-deg 8-min curve. No flaking was found in any of the special high-carbon rails but head checks were noted in several in the high side of the 4-deg 8-min curve.

A variation was apparent in the flow or batter at the ends of some of the standard-analysis rails, and small chipped-out areas were noted, especially in the 4-deg 8-min curve. The ends of the high carbon rails appeared to be standing up very well.

NORFOLK & WESTERN RAILWAY SERVICE TESTS

Service Test of Curvemaster and Fully Heat-Treated Rails

A service test of Curvemaster and fully heat-treated rails was installed on February 3, 1964, on two compound curves in the same track at M.P. 349 in the Bradford District, 13 miles east of Bluefield. The right-hand curve with the fully heat-treated rail meets the left-hand curve with the Curvemaster rail at bridge 825. Sixty percent of the traffic on these curves is westbound. The speeds are 30 mph for passenger and 25 mph for freight trains. At the time of the inspection on October 6, 1964, 20 million gross tons of traffic had passed over these curves. The flow of the ends of the Curvemaster rail was more pronounced than that of the fully heat-treated rails. The curve oiler was operating on both curves.

On the right-hand curve 25 fully heat-treated rails were installed on both the high and low sides. This is a 10-deg, 57-min, 9-deg 50-min and 11-deg 04-min curve with a westward 1.225 percent ascending grade. It has a 4-in superelevation. The length is 480.8 ft.

On the left-hand curve, 25 Curvemaster rails were installed on the high and low sides. This is a 10-deg 23-min and 11-deg 8-min curve with a westward 1.105 percent ascending grade. It has a 4-in superelevation and is 427.9 ft long.

Fully Heat-Treated Rail at Maken, W. Va.—6 Deg Curve, M.P. 481+210 Ft

Sixty-six fully heat-treated rails were installed in both the high and low sides of the 6 deg curve at Maken, W. Va., on August 2, 1954. On September 21, 1959, after the rails had been in service 5 years and had carried 168,900,000 gross tons of traffic, they were transposed, high rails to the low side and low rails to the high side of the curve. Last year, inspection showed six rails with medium flaking and four rails with heavy flaking. This condition had not changed at the October 7, 1964 inspection at 425 million gross tons of traffic.

Fully Heat-Treated Rail at Looney's Curve, W. Va.—Compound 4–7–12 Deg. Curve, M.P. 44 + 582 Ft

Fifty-five fully heat-treated rails were laid in the high side and 54 in the low side of this compound curve on August 2 and 9, 1954. The report of May 11, 1961, reflected progression of the service developments, particularly in the high-side rail. In September 1961, the rails of the high side were replaced with fully heat-treated rail. The low-side rails showed some deformation due to crushing but were not removed. This condition had not changed at the October 9, 1964, inspection after 231 million gross tons of traffic.

Appendix 8–b

Shelly Rail Studies at the AAR Research Center

The shelly rail study formerly conducted at the University of Illinois by Professor R. E. Cramer has been continued at the AAR Research Center. The rolling-load test results obtained in the cradle-type machine are listed in Table 1.

Tests 1224 A and B are a continuation of the work at the University of Illinois. Fig. 1 shows a macrograph of the cross section of rail 1224 A that shelled at 2,773,000 cycles. Rail 1236 B is still under test. The rolling-load tests of the manganese-vanadium rails, S–1 A and B, have been completed. The shelly failure at 1,311,000 cycles is shown on Fig. 2. The investigation of the results of mechanical properties is in progress. The flame-hardened rails in tests S–2 and S–3, for the C&O and L&N, failed at 296,900 to 2,150,800 cycles with a typical crack at the heat-affected zone, as shown on Fig. 3. A typical hardness pattern produced by this process is shown on Fig. 4. The rolling-load tests of the induction-hardened rail submitted by the PRR, under numbers S–4 A, B and C, show excellent results. The hardness pattern and the heat pattern can be observed on Fig. 5. The excellent hardness pattern and heating pattern of the flame hardened and water-oil emulsion quenched rails of tests S–5 A and B, are shown on Fig. 6. The shelly crack on rail S–5 A, at 1,447,400 cycles, is shown on Fig. 7.

Because of the small depth of the uniform hardness in the flame-hardened and induction-hardened rail, it has been found impractical to obtain their mechanical properties.

The slow-bend test results, shown on Table 2, were obtained at the Research Center from August 1, 1963, to October 1, 1964. The test was made with the rail head up on supports 48 in apart. The load was applied at two points, one on each side of and 6 in from the mid-point of the span. Thus, the applied bending moment between these load points in inch-pounds was nine times the applied load. It can be noted that all of the rails tested showed excellent results and that no effective stresses were set up between the head and web due to flame and induction hardening.

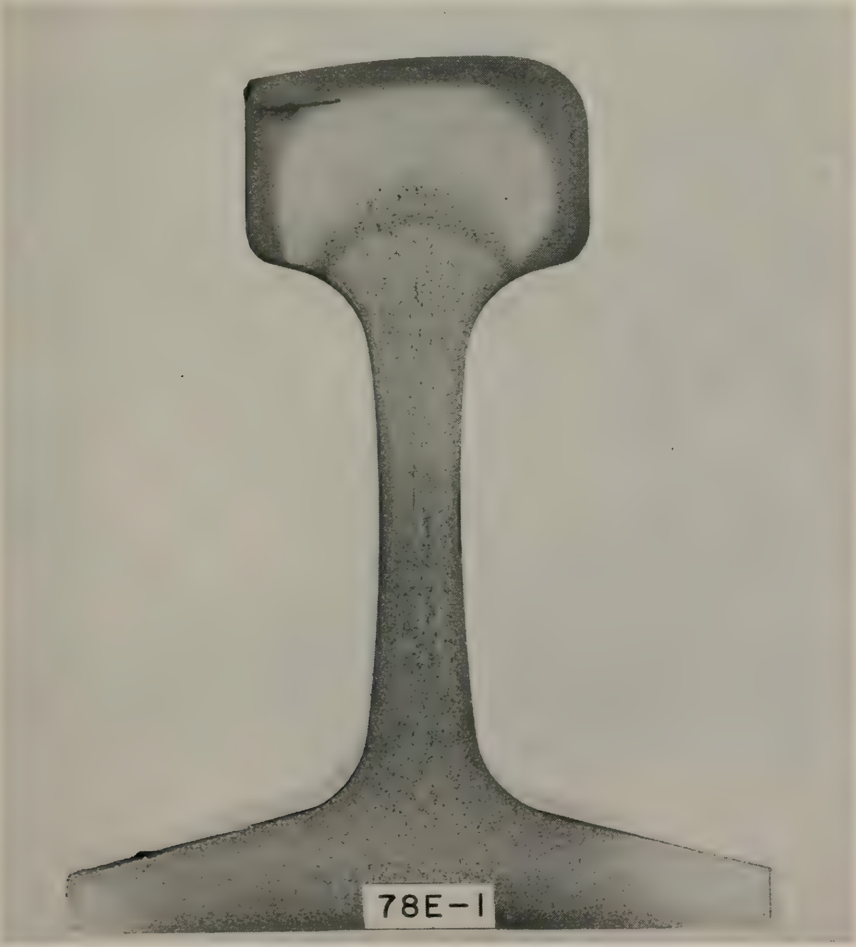


Fig. 1—Macrograph of a cross section of a Japanese induction-hardened rail, test 1224 A, showing the shelly crack.

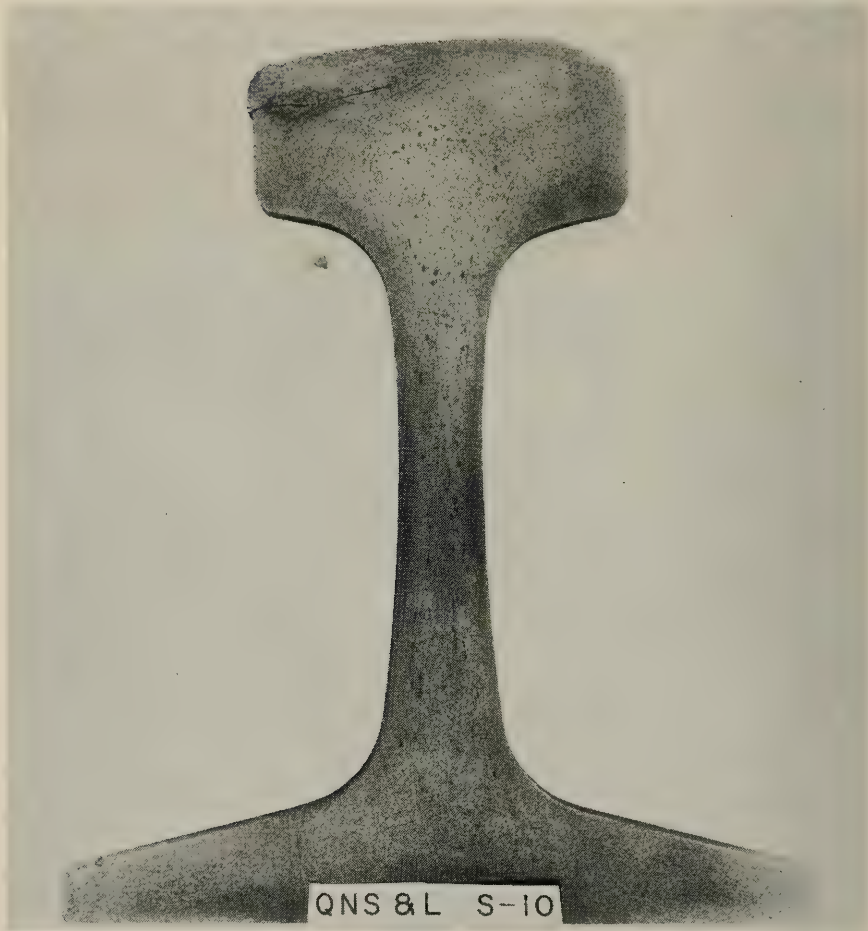


Fig. 2—Macrograph of a cross section of manganese-vanadium rail S-1 A, showing the shelly failure at 1,311,000 cycles.

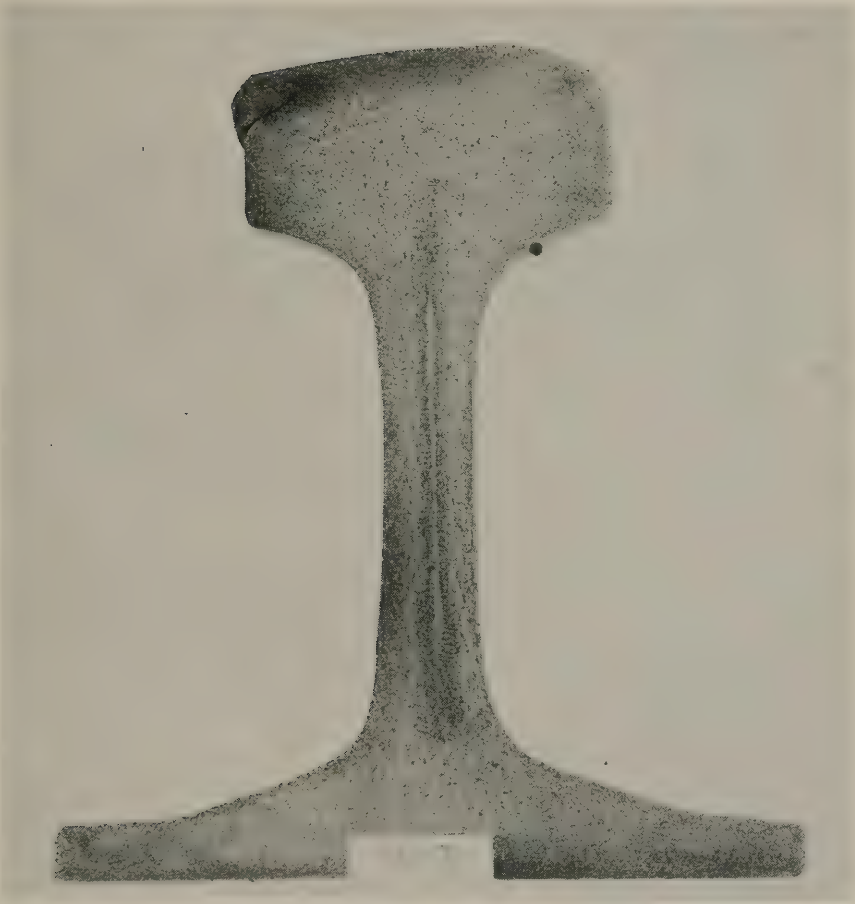


Fig. 3—Macrograph of the cross section of a flame-hardened rail, showing the shelly failure.

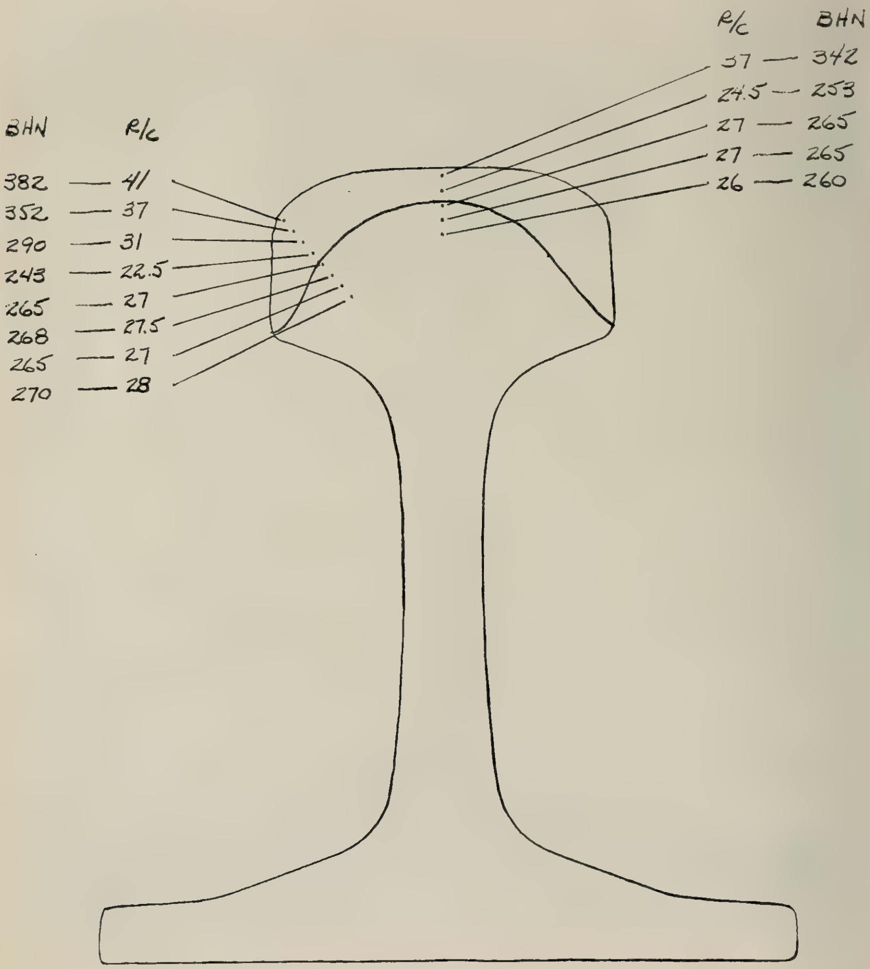


Fig. 4—Typical hardness pattern of a flame-hardened rail.

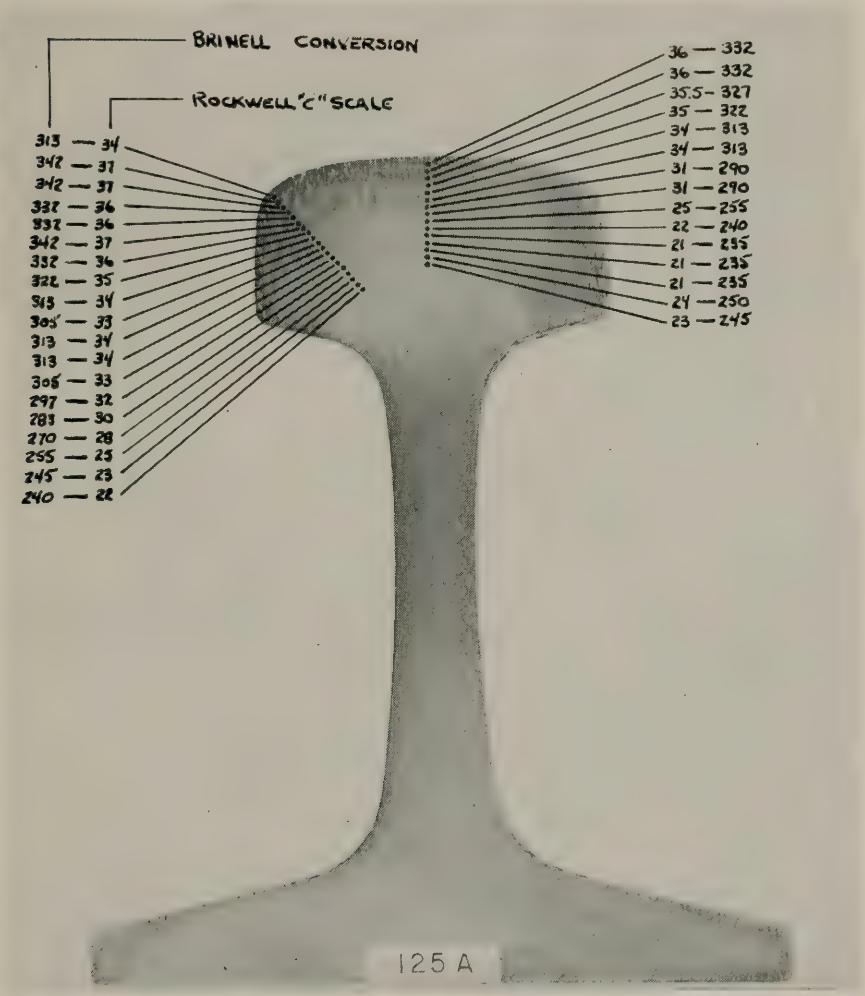


Fig. 5—Macrograph of a cross section of an induction-hardened rail, showing the hardness and heating pattern.

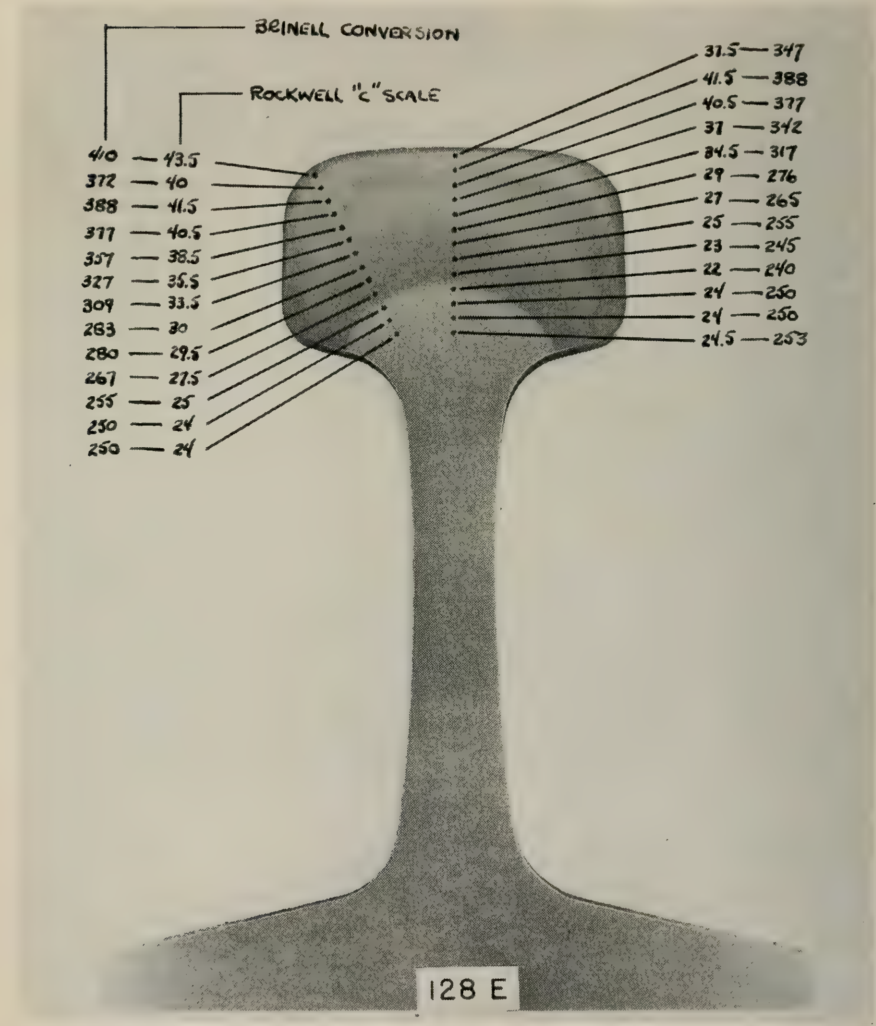


Fig. 6—Macrograph of a cross section of a flame-hardened rail, showing the hardness pattern.

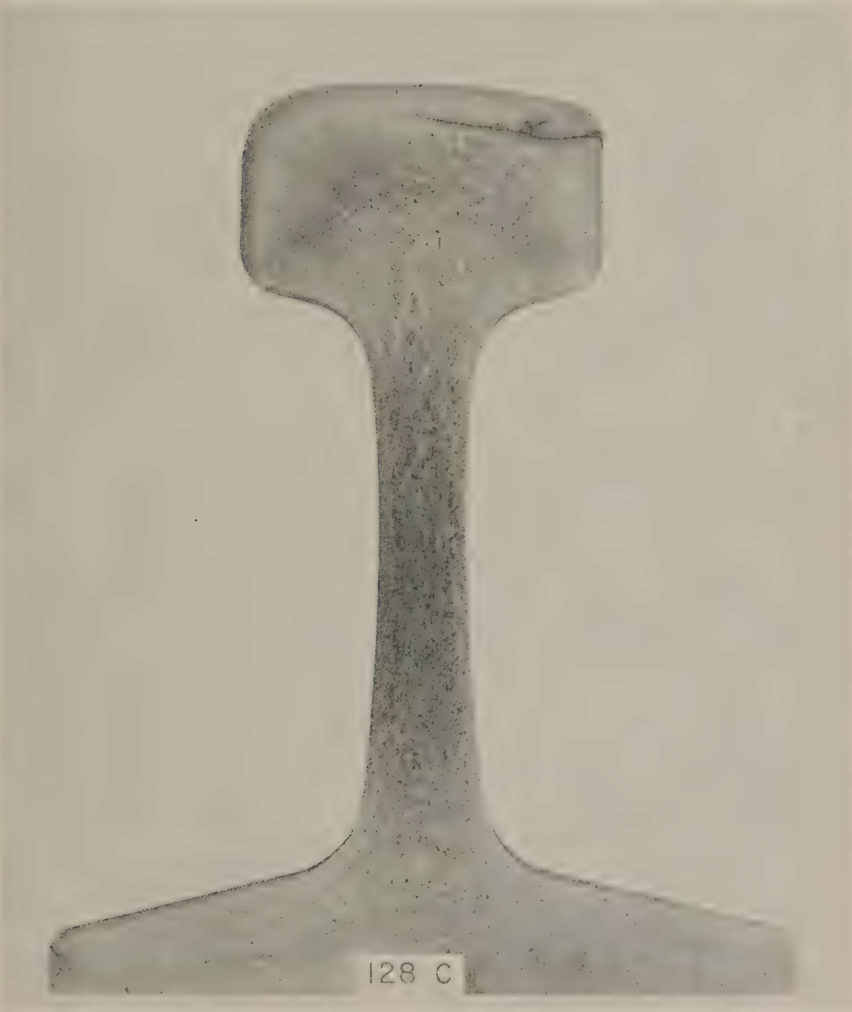


Fig. 7—Macrograph of a cross section of flame-hardened rail S–5 A, showing the shelly crack at 1,447,400 cycles.

TABLE 1
MECHANICAL PROPERTIES AND ROLLING LOAD TESTS
AAR Research Center, (August 1. 1963 to October 1, 1964)

Spec. No.	Chemical Analysis				Size and Kind of Rail	Brin. Hard.	Yield Strength .2% Offset psi	Tensile Strength psi	Elong. in 2 in. %	Red. of Area %	Charpy No Notch	Value Key Hole	Endurance Limit psi	Cycles for Failure of 50,000 lb. Wheel Load
	C	Mn	Si	V										
1224 A B	.72	.72	.18		119 lb. Ind. Hardened Japanese Rail	320 Avg.	121,700	160,200	12.6	43.0	351	10.1	89,000	2,773,000 5,000,400*
1236 A B					133 lb. U. P. Used Flame Hardened	340 Avg.								1.826,000
S-1 A B	.56	1.53 CR. .32	.26	.085	132 lb. Dosco Mn.-V. Alloy Rail for QNS&L									1,311,300 5.154,000**
A S-2 B C					122 lb. Gary Rail Flame Hardened for the B&O--C&O	253-382								296,900 1,476,800 2,150,800
S-3 A B					132 lb. Tenn. Rail Flame Hardened for the L&N	265-322								1,265,100 1,835,900
A S-4 B C					132 lb. U.S.S. Rail Induction Hardened for the PRR	283-342								3,180,800 8,000.000* 5,000,000*
A S-5 B C	.78	.78	.14		136 lb. CF&I Rail Flame Hardened in Germany for the D&RGW	318-347 283-377 283-410								1,447,400 2,159,700 8,000,000*

*No shelling crack found.

**Test stopped because of cracks in bolt hole area.

TABLE 2
SLOW BEND TEST RESULTS OF RAILS
AAR Research Center, (August 1, 1963 to October 1, 1964)

Spec. No.	Rail Section Lb./Yd.	Rail-road	Type of Rail Treatment	Max. Load Lb.	Max. Defl. In.	Energy to Max. Defl. Ft. Lb.	Remarks
5	122 CB	B&O	Exp. Sect. Machined	457,000	4.0	117,500	Did not break.
3	122 CB	B&O	Exp. Sect. Machined	449,000	4.0	115,000	Did not break.
4	122 CB	C&O	Flame Hardened	474,000	4.0	124,166	Did not break.
6	122 CB	C&O	Flame Hardened	474,000	4.0	122,916	Did not break.
7	136 CF&I	D&RGW	Flame Hardened	533,000	4.0	140,000	Did not break.
8	136 CF&I	D&RGW	Flame Hardened	567,000	4.0	146,500	Did not break.
1	140 RE	PRR	Induction Hardened	606,000	4.0	157,083	Did not break.
2	140 RE	PRR	Induction Hardened	603,000	4.0	165,416	Did not break.

Report on Assignment 9

Standardization of Rail Sections

J. B. Clark (chairman, subcommittee), S. H. Barlow, B. Bristow, J. A. Bunjer, T. F. Burris, M. W. Clark, C. J. Code, C. A. Colpitts, W. J. Cruse, O. E. Fort, C. E. R. Haight, C. J. Henry, C. C. Herrick, T. B. Hutcheson, B. R. Meyers, C. E. Morgan, Embert Osland, G. L. P. Plow, R. C. Postels, D. H. Shoemaker, H. F. Smith, E. H. Waring, W. L. Young.

This is a progress report, submitted as information.

During the year Subcommittee 9 presented informal discussions at meetings of the Rail Committee of the 122-lb rail section rolled for the first time since the last report of this committee. The amount of rail of that section rolled will be included in the next tabulation of Rail Rolled by Weight and Sections, which is scheduled to be included in the next report of this committee.

Report on Assignment 10

Service Performance and Economics of 78-Ft Rail Specifications for 78-Ft Rail

Collaborating with Committee 5

A. P. Talbot (chairman, subcommittee), W. D. Almy, S. H. Barlow, H. B. Berkshire, R. M. Brown, J. A. Bunjer, R. E. Catlett, Jr., J. T. Collinson, J. H. Greason, Jr., T. B. Hutcheson, J. C. Jacobs, H. W. Jenkins, A. V. Johnston, R. R. Lawton, F. R. Micheal, H. R. Moore, C. E. Morgan, J. S. Parsons, G. C. Payne, R. B. Rhode, J. G. Roney, G. L. Todd, J. H. Watts, C. E. Weller.

This is a progress report, submitted as information.

Cost data on three test stretches of 78-ft rail on the Pennsylvania Railroad, which were installed in 1950, is being maintained. No major track work has been done on these stretches in 1964 to alter the cost data reported in 1963.

Field measurements of joint gap and batter on the AAR test stretches at Hamlet, Ind., on the PRR, and Monee, Ill., on the Illinois Central were deferred again this year, but are programmed to be made in 1965.

Report of Committee 5—Track

J. M. Salmon, Jr.,
Chairman

C. E. Peterson,
Vice Chairman

V. M. Schwing, *Secretary*

R. J. Hollingsworth
T. L. Biggar
C. J. McConaughy
C. N. King
L. A. Pelton
E. C. Honath
R. G. Garland
S. H. Poore
L. W. Green
H. W. Jensen
A. B. Hillman, Jr.
G. R. Sproles
M. C. Bitner
W. R. Bjorklund
J. R. Bowman
E. W. Caruthers (E)
G. P. Chandler
J. W. Clarke
J. P. Collins
W. E. Cornell
E. D. Cowlin
F. W. Creedle
C. D. Davis
A. D. DeMoss
K. E. Dunn
J. J. Eash
L. D. Freeman
B. J. Gordon
W. E. Griffiths
L. R. Hall
C. N. Harrub, Jr.
M. J. Hassan
A. E. Haywood
N. W. Hillegass
A. F. Huber (E)
F. E. Huddleston
L. H. Jentoft
B. J. Johnson
C. H. Johnson
L. T. Klauder
G. G. Knupp
R. E. Kuston
E. J. Lisy, Jr.
M. P. Moore
C. W. Morrison
A. C. Parker, Jr.
B. E. Pearson
Bernard Post
Ross P. Roden
R. N. Schmidt
R. D. Simpson
J. F. Smith
F. J. Swoboda
R. E. Tew
K. H. von Kampen
C. W. Wagner
S. J. Watson*
Troy West (E)
I. V. Wiley
J. B. Wilson
M. J. Zeeman (E)
Committee

(E) Member Emeritus.
* Died July 15, 1964.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 5.

To The American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.
   Progress report, with recommendations submitted for adoption .... page 497

2. Track tools, collaborating with Purchases and Stores Division AAR.
   Progress report, submitted as information .... page 498

3. Standardization of trackwork plans, collaborating with Communication and Signal Section, AAR.
   Progress report, with recommendations submitted for adoption .... page 499
   (a) Comparative service life of open-hearth steel switch points, flame-hardened switch points, heat-treated switch points and manganese steel switch points.
   Brief progress statement, submitted as information .... page 500
   (b) Comparative service life and economy of spring-rail frogs vs. rigid frogs of open hearth steel, rail-bound manganese steel and heat-treated, open-hearth, rail-bound manganese steel.
   Brief progress statement, submitted as information .... page 500
   (c) Bridge rail expansion joints—types, location and necessity.
   Brief progress statement, submitted as information .... page 500

4. Prevention of damage resulting from brine drippings on track and structures, collaborating with Committee 15 and Mechanical Division, AAR.

   Because of restricted AAR Research Department funds and personnel, nothing was accomplished in 1964.

5. Tie plates, collaborating with Committees 3 and 4.

   Because of restricted AAR Research Department funds and personnel, no inspection was made in 1964 of the Oakdale test of rubber abrasion plates on the Pennsylvania Railroad.

6. Hold-down fastenings for tie plates, including pads under plates; their effect on tie wear, collaborating with Committee 3.

   Because of restricted AAR Research Department funds and personnel, the results of the London, Ky., test on the Louisville & Nashville were not published in 1964. It is hoped that your committee will present a final report and Manual material in 1966.

7. Effect of lubrication in preventing frozen rail joints and retarding corrosion of rail and fastenings.

   Because of restricted AAR Research Department funds and personnel, nothing was accomplished in 1964.

8. Laying rail tight with frozen joints.

   Final report, submitted as information .... page 500

9. Critical review of the subject of speed on curves as affected by present-day equipment, collaborating with AAR Joint Committee on Relation Between Track and Equipment.

   Final report, with recommendations submitted for adoption .... page 501

   (a) Special requirements of track construction and maintenance due to operation of equipment with high center of gravity and/or hydraulically cushioned underframes.

   No report.

10. Methods of heat treatment, including flame hardening, of bolted rail frogs and split switches, together with methods of repair by welding; explosive hardening of manganese-steel trackwork.

    Progress report, submitted as information .... page 503

11. Practicability of using reflex units for switch lamps and targets, collaborating with Communication and Signal Section, AAR.

    Progress report, submitted as information .... page 504

12. Procedure and specifications for, and economies to be derived from, building track by the panel method:

    (a) Where track is to be newly constructed.

    (b) Where track now laid in conventional staggered-joint construction is to be relocated from one point to another:

      (1) To remain as paneled after relocation.

      (2) To have its joint restaggered after relocation.

(c) Specifications, plans and procedures for prefabricating turnouts in a central shop.
(d) Methods of moving prefabricated turnouts from a central shop to point of use.
(e) Methods of handling a prefabricated turnout at point of renewal or installation.

Study in progress; however, sufficient information is not at hand to justify making a report.

THE COMMITTEE ON TRACK,
J. M. SALMON, JR., *Chairman.*

AREA Bulletin 591, February 1965.

MEMOIR

Stewart J. Watson

Stewart J. Watson, chief draftsman, Chicago & North Western Railway, died at the Illinois Central Hospital, Chicago, on July 15, 1964. He is survived by his wife, Flora, and a son, John, both of Chicago, and a daughter, Mrs. Jean August of Palos Heights, Ill.

Mr. Watson was born in Chicago, January 27, 1894, and received his engineering education at the Chicago Technical College.

He entered the service of the C&NW on April 22, 1914, as a tapeman. He advanced to rodman, instrumentman, inspector and draftsman in the Engineering Department and was appointed chief draftsman in the chief engineer's office on August 1, 1956, which was the position he held at the time of his death.

Mr. Watson became a member of the American Railway Engineering Association and Committee 5 in 1956. He gave generously of his time to committee work and was admired by all of his associates who had the privilege of working with him. It with sorrow and regret that we record his passing.

V. M. SCHWING,
H. W. JENSEN,
C. E. PETERSON,
Committee on Memoir.

Report on Assignment 1

Revision of Manual

R. J. Hollingsworth (chairman, subcommittee), L. R. Hall, M. J. Hassan, A. F. Huber, H. W. Jensen, G. G. Knupp, L. A. Pelton, C. E. Peterson, S. H. Poore, J. M. Salmon, Jr., J. F. Smith, G. R. Sproles, M. J. Zeeman.

Your committee submits for adoption an addition to the Specifications for High Carbon Steel Track Spikes to provide for an alternate when ladle analysis cannot be furnished, similar to the one provided for in the Specifications for Soft Steel Track Spikes.

The specific recommendations of your committee are as follows:

Pages 5–2–3 to 5–2–5, incl.

SPECIFICATIONS FOR HIGH-CARBON STEEL TRACK SPIKES

Reapprove with the following revisions:

Pages 5–2–3 and 5–2–4: Designate the present paragraph of Art. 4—Ladle Analysis, as Para. (a) and add the following new Para. (b):

"(b) When ladle analysis cannot be furnished, the manufacturer shall submit a report of the chemical analysis made on three spikes selected at random from each 10-ton lot."

Report on Assignment 2

Track Tools

Collaborating with Purchases and Stores Division, AAR

T. L. Biggar (chairman, subcommittee), W. R. Bjorklund, E. W. Caruthers, W. E. Cornell, A. E. Haywood, C. H. Johnson, C. N. King, C. E. Peterson, S. H. Poore, Bernard Post, J. M. Salmon, Jr., J. F. Smith.

This is a progress report, submitted as information.

1. Snap-on Track Wrenches

The study on snap-on track wrenches has been dropped. It was found that the cost to manufacture such a tool is prohibitive.

2. Reclamation of Hand Tools

Study reveals that a saving of 69.5 percent is possible to railroads in reclaiming and repairing small tools in their own shops.

Striking and cutting tools can be restored to their original contours provided that not more than 10 percent of their weight is lost in the process. When more weight than that is lost, the efficiency of the tool is so reduced that it is not advisable to keep it in service.

3. Aluminum Combination Track Level and Gage

A combination track level and gage has been designed and suggested modifications in the design have been made. However, the latest drawing has not been approved by the committee.

Report on Assignment 3

Standardization of Trackwork Plans

(a) Comparative Service Life of Open-Hearth Steel Switch Points, Flame-Hardened Switch Points, Heat-Treated Switch Points, and Manganese-Steel Switch Points

(b) Comparative Service Life and Economy of Spring-Rail Frogs Vs. Rigid Frogs of Open-Hearth Steel, Rail-Bound Manganese Steel, Heat-Treated Open-Hearth Rail-Bound Manganese Steel

(c) Bridge Rail Expansion Joints—Types, Location and Necessity

C. J. McConaughy (chairman, subcommittee), T. L. Biggar, W. R. Bjorklund, J. R. Bowman, J. P. Collins, W. E. Cornell, F. W. Creedle, C. D. Davis, A. D. DeMoss, C. N. Harrub, Jr., M. J. Hassan, N. W. Hillegass, R. J. Hollingsworth, E. C. Honath, F. E. Huddleston, H. W. Jensen, B. J. Johnson, C. H. Johnson, C. N. King, G. G. Knupp, R. E. Kuston, E. J. Lisy, Jr., C. W. Morrison, A. C. Parker, Jr., B. E. Pearson, C. E. Peterson, Bernard Post, Ross P. Roden, J. M. Salmon, Jr. R. N. Schmidt, V. M. Schwing, R. D. Simpson, G. R. Sproles, J. F. Smith, F. J. Swoboda, K. H. von Kampen, I. V. Wiley.

In keeping with the decision to keep up to date the plans in back of the blue divider sheet in the Portfolio of Trackwork Plans that separates the "standard" plans from the others, your committee submits for adoption the following recommendations:

Plan No. 405–55, No. 10 Spring Rail Frog, Short Spring Rail Type

Plan No. 408–55, No. 9, No. 11 and No. 12 Spring Rail Frogs, Short Spring Rail Type

Remove both of these plans from the Portfolio.

Plan No. 490–55, Diagram Illustrating Preferred Names of Parts for Spring Rail Frogs.

Delete drawing of Left-Hand Spring Rail Frog, Short Spring-Rail Type.

Appendix A–59, Page 3, Article 405, Physical Requirements and Tests

Revise (a–2) to read: "When bend tests are specified, the test specimens shall stand being bent cold through 150 degrees without breaking around a pin 1″ in diameter. The specimen may be bent in any method preferred by the manufacturer."

Study is in progress of Plans 15–62, sheet 1, and 20–62, sheet 1, with the view of reducing the number of short ties in the center portion of the crossover. Indications are that tie arrangements similar to Plan 912–58 will avoid difficulty in maintaining gage through the crossover under the heavier wheel loads and higher permissible speeds now in effect. It is hoped to present these revisions for adoption as Manual material in 1966.

Plan 820–50, Graph Showing Limitations for the Use of Crossings with Rigid Center Frogs, permits the use of rigid frogs with angles less than 9 deg 30 min in yards and terminals. Experience has shown that the use of rigid center frogs of angles smaller than No. 8 (9 deg 30 min) can create a hazardous condition. This matter is being investigated and a report will be submitted in 1966.

Plan 774–55, Crossings with Solid Manganese Steel Frogs and Interior Rolled Closure Rails, Angles Below 25 Deg 00 Min and Above 14 Deg 15 Min, Single-Rail Construction; and Note 5 of Plan 820–50, Graph Showing Limitations for the Use of Crossings with Rigid Center Frogs, both correctly show parallel flangeways 1⅞ in wide. However, Plan 775–55, Crossings with Solid Manganese Steel Frogs and Interior Rolled Closure Rails, Angles 14 Deg 15 Min to 8 Deg 10 Min 16 Sec. Incl., Single-Rail Construction, shows tapered flangeways 1⅞ to 2¼ in wide on the outside. This is an error, and Plan 775–55 will be corrected to show parallel flangeways 1⅞ in wide.

Your committee has investigated the rash of failures that have occurred in special trackwork bolts where the heads have separated from the shank. In practically all cases there was evidence of a fracture or crack due to the lack of a fillet radius on the shank under the bolt head. The specification for this bolt in the Trackwork Plans Portfolio, Appendix A, Section 1402, reads: "Heads—American Standard regular square heads (ASA B–18.2—1941), or any later revision thereof, except where otherwise shown on detail plans." The American Standards Association is revising Specification B–18.2 to include a definite radius under the bolt head for the various bolt diameters, so no change in the AREA specification is required.

Report on Assignment 3 (a)

Work is continuing on Assignment 3 (a). No comparison is possible at this time because it appears that there are no records available, nor have studies of this nature been made by any of the railroads.

Report on Assignment 3 (b)

Assignment 3 (b) has been requested to be discontinued. The spring rail, the railbound manganese and the self-guarded manganese frogs are designed for different and separate uses; therefore, it is not considered practicable to make a meaningful comparison. In lieu thereof, your committee is attempting to develop Manual material suggesting the desirable usage of the various types of frogs.

Report on Assignment 3 (c)

Assignment 3 (c) is being progressed. It has been expanded to include all types of track expansion rails, and the committee hopes that from its study Manual material can be developed.

Report on Assignment 8

Laying Rail Tight with Frozen Joints

S. H. Poore (chairman, subcommittee), M. C. Bitner, G. P. Chandler, F. E. Huddleston, C. E. Peterson, Ross P. Roden, J. M. Salmon, Jr., R. N. Schmidt, R. E. Tew, C. W. Wagner, J. B. Wilson.

Three installations of rail laid tight with frozen joints have been under examination by the Committee, as follows:

1. On the Louisville & Nashville near Chapel Hill, Tenn., laid in November 1953.
2. On the Erie (now the Erie Lackawanna) near Crown Point, Ind., laid in July 1957.
3. On the Bessemer & Lake Erie, Grove City, Pa., laid in October 1957.

Complete descriptions of these installations appear in the Proceedings of the AREA Volumes 57, 59, 60, 61 and 62, in the reports of the Track committee.

Adjacent to the L&N and Erie installations there was laid a comparable amount of conventional jointed rail for comparison. However, no control section was laid on the B&LE. In all three test sections the rail was laid on good ties with large tie plates and with an ample ballast section. Six-hole joint bars were used in all cases. Initial bolt tension was 35,000 to 40,000 lb on the L&N, 35,000 lb on the Erie and 45,000 lb on the B&LE.

On all three sections bolts were retightened at various times. End batter and metal flow occurred. On the L&N test all but 51 of 211 frozen joints chipped badly (maximum chip size ⅛ in wide and 1 in long) and required welding. No record of chipped joints is available for the Erie or the B&LE installations.

No significant difference was found in the performance of the rail laid tight with high bolt tension compared with the jointed rail laid at the same time with normal bolt tension.

It does not appear to your committee that rail laid with no expansion gap and with bolts tightened to a tension of 35,000 to 40,000 lb offers any worthwhile advantage over jointed rail laid in the usual manner. The joints in the tight rail require periodic maintenance, either to keep the bolts tight or to relieve metal flow. Furthermore, it does not appear that tight rail offers any advantage over the use of continuous welded rail.

This is a final report, presented as information.

Report on Assignment 9

Critical Review of the Subject of Speed on Curves as Affected by Present-Day Equipment

Collaborating with the AAR Joint Committee on Relation Between Track and Equipment

L. W. Green (chairman, subcommittee), J. R. Bowman, J. P. Collins, A. D. DeMoss, K. E. Dunn, J. J. Eash, L. R. Hall, A. B. Hillman, Jr., R. J. Hollingsworth, E. C. Honath, H. W. Jensen, L. H. Jentoft, B. J. Johnson, C. N. King, L. T. Klauder, R. E. Kuston, B. E. Pearson, C. E. Peterson, Bernard Post, J. M. Salmon, Jr., V. M. Schwing, R. E. Tew.

In Vol. 56 of the Proceedings, starting on page 127, there is published a lengthy treatise entitled "Passenger Ride Comfort on Curved Track." As a result of this treatise changes were recommended in ELEVATIONS AND SPEEDS FOR CURVES and SPEEDS OF TRAINS THROUGH LEVEL TURNOUTS, Part 3, Chapter 5 of the Manual, and adopted. The specific changes appear in Vol. 57, pages 764 through 767.

In the same treatise in Vol. 56 it was recognized that some revision was necessary in the formula for the length of spirals as specified by the AREA Manual. The treatise derived the formula $L = 4.88V$ as a possible substitute for the existing formula. Since publication of this treatise, your committee has spent a great amount of time considering the various aspects of the subject of proper length of spirals.

In AREA Bulletin 580 for September–October 1963, there is published an AAR research report (ER–37) which covers the results of extensive tests on the Pennsylvania Railroad made in June 1962, to obtain ride comfort data on cars running at different speeds on different lengths of spirals. This research report was again reviewed on page 516 of AREA Bulletin 584 issued in February 1964.

Your committee has now concluded its studies on proper spiral lengths and offers the following recommendations for adoption and publication in the Manual:

Pages 5–3–1 to 5–3–4, incl.

SPIRALS

Reapprove with the following revision:

Delete Art. 1—Purpose, on page 5–3–1, substituting therefor the following new Art. 1.

1. Purpose

A spiral or transition curve should be used in main-line tracks, if practicable, between tangent and curve or between the different degrees of curvature of a compound curve. A spiral is also desirable in all tracks other than main tracks, where practicable, between tangent and curves and between the different degrees of curvature of a compound curve. The form of the spiral should be such that the degree of curvature increases directly with the length. In other than main tracks with no superelevation, this permits the engine or car trucks to be directed gradually to their rotated position (required by a curve) rather than to be directed instantaneously. This will likewise tend to prevent distortion of the alignment of the main body of the curve due to the force required to produce angular acceleration. In main tracks with superelevation, this permits a uniform rate of change of elevation of the outer rail on the spiral and promotes best riding conditions by maintaining throughout the train passage from tangent to curve the desired relation between amount of superelevation and degree of curvature.

The desirable length of the spiral for tracks other than main tracks with no superelevation is the maximum possible consistent with economy and the purpose of the track layout.

a. The desirable length of the spiral for main tracks where the alignment is being entirely reconstructed or where the cost of the realignment of the existing track will not be excessive should be such that when passenger cars of average roll tendency are to be operated the rate of change of the unbalanced lateral acceleration acting on a passenger will not exceed 0.03 *g* per sec (1). Also, the desirable length in this case needed to limit the possible racking and torsional forces produced should be such that the longitudinal slope of the outer rail with respect to the inner rail will not exceed 1/744 (2), which is based on an 85-ft-long car.

The formulas recommended to obtain the above results are:

$$L = 1.63\ E_u\ V \qquad \text{.......................} (1)$$

in which

L (min) = desirable length of spiral in feet

E_u = unbalanced elevation in inches

V = maximum train speed in miles per hour

(If the spiral is to be designed for passenger equipment which has the car-body roll with respect to the track controlled by special designs, the length of spiral for this specific roll angle may be determined by the method and formula given on pages 94, 516 and 517, Vol. 65, AREA Proceedings.)

$$L = 62 \ E_a \quad \ldots\ldots (2)$$

in which

L (min) = desirable length of spiral in feet
E_a = actual elevation in inches

In using the above formulas for determining the length of spirals joining tangents and curves and joining curves of different radii, the maximum length of spiral produced by the two formulas should be used.

b. It is recognized that in the case of realignment of existing tracks, formula (1) may produce a length of spiral the construction of which would result in excessive costs. Therefore, in such cases it is felt that the length should be such that, with average roll tendency of passenger cars operated on the track, the rate of change of the unbalanced lateral acceleration acting on a passenger will not exceed 0.04 *g* per sec (3). In this case the maximum slope formula (2) should be retained.

The formula recommended for this case in lieu of formula (1) is

$$L = 1.22 \ E_u \ V \quad \ldots\ldots (3)$$

in which

L (min) = desirable length of spiral in feet
E_u = unbalanced elevation in inches
V = maximum train speed in miles per hour

In using formulas (2) and (3) for determining the length of spirals joining tangents and curves and joining curves of different radii, the maximum length of spiral produced by the two formulas should be used.

Report on Assignment 10

Methods of Heat Treatment, Including Flame Hardening, of Bolted Rail Frogs and Split Switches, Together with Methods of Repair by Welding; Explosive Hardening of Manganese Steel Trackwork

H. W. Jensen (chairman, subcommittee), M. C. Bitner, W. R. Bjorklund, J. R. Bowman, J. P. Collins, F. W. Creedle, C. D. Davis, A. D. DeMoss, A. R. DeRosa, W. E. Griffiths, M. J. Hassan, C. N. Harrub, Jr., A. E. Haywood, C. H. Johnson, G. G. Knupp, R. E. Kuston, C. W. Morrison, A. C. Parker, Jr., C. E. Peterson, Ross P. Roden, J. M. Salmon, Jr., R. D. Simpson, J. F. Smith, F. J. Swoboda, R. E. Tew, K. H. von Kampen, C. W. Wagner, I. V. Wiley, M. J. Zeeman.

Service Test of Simulated Crossings

The service test of the 24 simulated flangeway intersection units of bolted rail construction in the Milwaukee Road's westward freight main leading to the Bensenville hump yard at Mannheim, Ill., was again inspected in September 1963. At that time, which was six years after the experimental welding processes had taken place on all the units, it was decided that the service period had been of sufficient duration to afford conclusive results. Accordingly, the test panels were removed from track in November 1963 and the receiving sections of the running rails from each unit were sent to the Research Center for a metallurgical examination and final correlation of the field test data.

At the time of removal, the units had carried a total of 299 million gross tons of traffic since their installation in 1954, of which 208 million gross tons were after the welding of the units in September 1957.

Your committee is now reviewing the complete report on this service test as submitted by the Research Center, which will be published as an Engineering Research Report (ER–51). It is anticipated that your committee will present a final report with possible Manual material next year.

Explosive Hardening of Manganese Steel Trackwork

Study has continued on this subject; however, your committee does not feel it has sufficient information at hand to justify a report. Research funds for this work have been lacking for the past few years.

Report on Assignment 11

Practicability of Using Reflex Units for Switch Lamps and Targets

Collaborating with Communication and Signal Section, AAR

A. B. Hillman (chairman, subcommittee), G. P. Chandler, J. W. Clarke, C. D. Davis, L. T. Klauder, C. J. McConaughy, M. P. Moore, B. E. Pearson, C. E. Peterson, J. M. Salmon, Jr., V. M. Schwing, J. F. Smith, C. W. Wagner, J. B. Wilson.

This is a report of the progress made since publication of the report in Bulletin 584, February 1964, page 517

A questionnaire was mailed to the chief engineers of the 36 largest railroads in the United States plus the Canadian National and Canadian Pacific on November 29, 1963. To date, replies have been received from 24 roads. Of the 24 only 2 roads reported that they were not using reflex units. One of the two stated that it was planning to use reflectorized targets wherever possible; the other indicated that it was doing away with all switch lamps.

Fourteen roads representing 104,714 miles reported 37,200 units in service, including 8,947 switch targets with reflex material. The type of installation preferred is four reflex lenses mounted in a housing to replace switch lamps. The second preference is the use of sheet-type reflex material on switch targets. Third in preference is the use of two red reflex lenses mounted back to back, to replace switch lamps.

Five roads not included in the fourteen mentioned above indicated the following usage of reflex units:

1. Yellow and green reflex lenses back to back on all yard stands.
2. Several hundred installations of two red reflex lenses mounted back to back to replace switch lamps and 40 to 50 installations with sheet-type reflex material on switch targets.

3. Have adopted as standard the use of reflectorized targets, using only the red indication, for all main-line and branch-main-track switches, and yellow reflectorized targets for yard and back-track switches, except in locations where night switching is performed and there is insufficient illumination for reflex targets to be effective.
4. Have test installations of four reflex lenses mounted in a housing to replace switch lamps, and reflex lenses to replace lenses in switch lamps. Have several hundred installations with sheet-type reflex material on housing to replace switch lamps.
5. Two-hundred installations with four reflex lenses mounted in a housing to replace switch lamps and 50 percent of the main line equipped with sheet-type reflex material on switch targets. This road indicated that it has adopted red reflex targets as standard on all main-line switches as a safety feature but was continuing to use lamps on these switches.

Seventeen roads provided cost data, with annual costs ranging as follows:

Oil lamps	$22.15 to $240.00
Electric lamps	$10.00 to $ 40.00
Reflex units	$ 1.15 to $ 5.00

Eliminating the $240.00 figure for oil lamps and the $10.00 figure for electric lamps, the following average annual costs, which appear to cover labor, material and depreciation, were calculated:

Oil lamps	$49.17
Electric lamps	$23.73
Reflex units	$ 3.16

To date, it has been determined that the following states have no restrictions on the use of reflex units for switch lamps: Alabama, Delaware, Georgia, Iowa, Kentucky, Maryland, New York, North Carolina, South Carolina, Tennessee, Virginia and West Virginia.

States which have restrictions and a brief description of the restrictions follow:

Illinois—No change may be made in the lighting of main-track switch stands without authority of the Illinois Commerce Commission.

Indiana—Main track—lamps required on all main-track switch stands. Side track—lamps not required on purely yard switching tracks, providing switch is not a point of connection with a main track. Derails—lamps required on all derails except those connected with home signal at interlocking or those used exclusively for private purposes.

Michigan—Requires lights from sunset to sunrise on main-track switches except where switches are electrically locked and within the limits of an interlocking plant or in centralized traffic controlled territory or automatic block territory. Lights are also required on derails except on tracks used exclusively for private purposes, connected to home signals at interlockers, or located on short lines of 100 miles or less or on lines where night trains are not operated.

Missouri—Reflex lenses not permitted in main-line territory unless in TCS or block signal territory.

Nebraska—Section 74-581 of Nebraska Revised Statutes requires "proper lights" on all main-line switch stands except in territory fully equipped with automatic block signals. The Supreme Court of Nebraska has interpreted the phrase "proper lights" to specifically exclude the use of reflectorized devices in lieu of burning lights.

Ohio—The Public Utilities Commission has authority to order the use of switch lamps at specific locations. Lamps that have been installed pursuant to commission order should be maintained.

Pennsylvania—Main track—lamps required on switch stands connected with a main track or passing siding track, except where the track is used only in dayight or is protected by automatic block signals, cab signals or train controls, or by a distant switch signal or indication in manual block or train order territory. Side track—lamps required on yard tracks over which there is a substantial movement at night (five or more movements between sunset and sunrise). Derails—no lamps required.

CONCLUSIONS

The current reporting of 37,200 units in service on 14 roads representing 104,714 miles of track plus an indeterminate number on five additional roads as compared with 10,754 units in service on 25 roads representing 98,353 miles of track reported in 1942, coupled with the savings to be realized as evidenced by the annual cost figures, indicate that the use of reflex units is practicable.

To date your committee has information pertaining to the positions of 19 states on the use of reflex units. Your commitee will continue the study to determine the positions of other states.

Report of Committee 31—Continuous Welded Rail

W. J. Jones, *Chairman*
C. W. Wagner,
Vice Chairman
K. R. Kilburn, *Secretary*

A. H. Galbraith
O. E. Fort
R. E. Frame
J. R. Rymer
J. F. Beaver
W. D. Almy
M. P. Anderson
S. H. Barlow
E. J. Brown
J. E. Campbell
J. D. Case
W. E. Chapman
C. O. Conatser
L. S. Crane
E. M. Cummings
R. E. Dove
Emil Eskengren
H. C. Fox
R. G. Garland
B. J. Gordon
C. R. Harrell
E. M. Hodges

J. L. Hodgkinson
T. B. Hutcheson
H. W. Jenkins
B. J. Johnson
A. B. Lewis
J. A. MacNab
C. P. Martini
A. S. McRae
C. R. Merriman
C. E. Morgan
L. W. Neville, Jr.
S. H. Poore
B. R. Prusak
M. S. Reid
F. L. Rees
R. P. Roden
T. C. Shedd
R. B. Stampfle
E. H. Waring
C. E. Weller
J. R. Zadra

Committee

Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 31.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Fabrication.

Part 1—Report on Development of Specifications for Fabricating Continuous Welded Rail, presented as information .... page 508

Part 2—Report on Service and Detected Failures of Butt-Welded Rail Joints, presented as information .... page 509

Part 3—Report on Results of Rolling-Load and Slow-Bend Tests of Butt-Welded Rail Joints, presented as information .... page 514

2. Laying.

Part 1—Report on Development of Recommended Practices for Laying Continuous Welded Rail, presented as information .... page 517

Part 2—Statistics, presented as information .... page 517

3. Fastenings.

Progress report, presented as information .... page 518

4. Maintenance.

Progress report, presented as information .... page 518

5. Economics.

Progress report, presented as information .... page 519

6. Welding Secondhand Rail.
Progress report, presented as information .... page 519

THE COMMITTEE ON CONTINUOUS WELDED RAIL,
W. J. JONES, *Chairman.*

AREA Bulletin 591, February 1965.

Report on Assignment 1

Fabrication

A. H. Galbraith (chairman, subcommittee), S. H. Barlow, J. E. Campbell, C. O. Conatser, L. S. Crane, H. C. Fox, C. R. Harrell, J. L. Hodgkinson, W. J. Jones, A. B. Lewis, A. S. McRae, C. E. Morgan, S. H. Poore, B. R. Prusak, R. B. Stampfle, C. W. Wagner, J. R. Zadra.

Your committee presents its report on Assignment 1 in three parts. Part 1 is a progress report on the development of specifications for fabricating continuous welded rail. Part 2 covers the examination of service and detected failures of butt-welded rail joints. Part 3 furnishes the results of rolling-load and slow-bend tests of butt-welded rail joints. Parts 2 and 3 were prepared by Kurt Kannowski, former metallurgical engineer at the AAR Research Center.

Part 1—Development of Specifications for Fabricating Continuous Welded Rail

Before drafting a set of recommended alignment and finishing tolerances for fabricating continuous welded rail, your committee sought assurance that rail as furnished by the rail rolling mills would meet normal butt-welding requirements.

Your committee is represented on a Task Committee from Committee 4—Rail, which has completed an inspection of the five rail rolling mills in the United States to determine if new specifications were required to obtain rail suitable for butt welding.

It is the opinion of the Task Committee that rail suitable for butt welding can be produced under the current Specifications for Open-Hearth Steel Rails (Basic-Oxygen Process May Be Used at the Option of the Purchaser), Chapter 4, of the Manual, and that no change in these specifications is required for the present. Art. 19—Mill Practices, of the aforementioned specifications states:

> The entire process of manufacture shall be in accordance with the best current state of the art. It is expected that thoroughly deoxidized steel will be furnished, and that in every stage of manufacture strict adherence to the standards of the best practice of the individual mill will be observed.

This specification makes the mills responsible for using the best maintenance and rolling practices to produce rail that requires minimum straightening. But it was observed that present straightening presses are limited in their ability to make very small corrections and that making these corrections tends to compound any deviations in the other direction.

It was also concluded by the Task Committee that inspection by the railroads' own representatives is desirable. However, regardless of the type of inspection provided, including inspection by contract inspection bureaus, special training of the inspectors as to the road's requirements is necessary.

Part 2—Service and Detected Failures of Butt-Welded Rail Joints

During the period from October 1, 1963, to October 1, 1964, 14 service and detected failures of butt-welded rail joints were submitted for examination to the AAR Research Center. Macrographic and microscopic examinations of the welds and of both rails adjacent to the joint were made. The results of each examination were reported to the railroad that had submitted the failure and to the producer of the rail.

Since the majority of the butt welding rail in the United States is done by means of the electric flash process, the failures reported in Table 1 are predominantly in the welds produced by this process. Because of the thermal shock produced by this process in the relatively short heated portions at the ends of the rail, failures occur in rails with heavy segregation or fish tail which, before welding were in a homogeneous state, but opened into a discontinuity during the welding. Figs. 1 to 3, macrographs of cross sections of the rail adjacent to failed welds, illustrate the three conditions causing the failures shown on Table 1. The types of failures of butt-welded rail joints and the cause of the failures have been described extensively in the AREA Proceedings, Vol. 65, pages 615 to 629.

TABLE 1
SERVICE AND DETECTED FAILURES OF BUTT WELDED RAIL JOINTS
(August 1, 1963 to October 1, 1964)

Lab. Failed Rail No.	Source of Failed Rail	Size of Rail	Producer (Mill)	Heat No. Rail Letter Ingot No.	Date Rolled	Classification of Failure		Type of Weld
						Defective Weld	Rail Quality	
136-1	WP	136 lb	CF&I	61463-A-2 61463-C-2	Mid 1962		Heavy segregation in 61463-A-2	Electric flash butt weld
136-2	GN	115 lb	Lackawanna Illinois	39209-A-27 642912-C-3	10-1962 1-1963		Open pipe in 39209-A-27	"
136-3	GN	115 lb	Lackawanna "	37153-E-4 37150-C-14	10-1962 10-1962		Fish tail in 37150-C-14	"
136-4	GN	115 lb	Lackawanna "	37150-B-14 37150-H-34	10-1962 10-1962		Fish tail in 37150-H-34	"
136-5	SAL	115 lb	Tennessee "	F-838726 G-838726	3-1959 3-1959	Pop out of burner tips-Lack of fussion		Oxyacetylene pressure butt weld
136-6	C&O	132 lb	Lackawanna "	35096-A-29 35096-A-13	Unknown "		Pipe in 35096-A-29	Electric flash butt weld
136-7	QNS&L	132 lb	Unknown "	Unknown "	Unknown "	Electrode burn in base of rail		"
136-8	QNS&L	132 lb	Unknown "	Unknown "	Unknown "	"		"
136-9	SAL	115 lb	Tennessee "	819479-B-12 819475-G-15	4-1961 4-1961		Fish tail in CH 819475-G-15	Oxyacetylene pressure butt weld
136-10	C&NW	115 lb	Inland "	16207-H-20 22865-C-15	6-1953 6-1953		Fish tail in 16207-H-20	"
136-11	C&O	122 1/2 lb	Lackawanna "	24096-C-3 29105-D-12	2-1964 2-1964	Oxide intrapment in fussion zone		Electric flash butt weld
136-12	C&O	122 1/2 lb	Lackawanna "	26054-A-10 28055-A-8	1-1964 1-1964		Segregation in "A" rails	"
136-13	C&O	122 1/2 lb	Lackawanna "	41148-A-21 41148-A-7	Unknown "		Segregation and pipe in "A" rails	"
136-14	C&O	122 1/2 lb	Lackawanna "	41148-H-13 39147-E-26	Unknown "		Fish tail in 41148-H-13	Electric flash butt weld

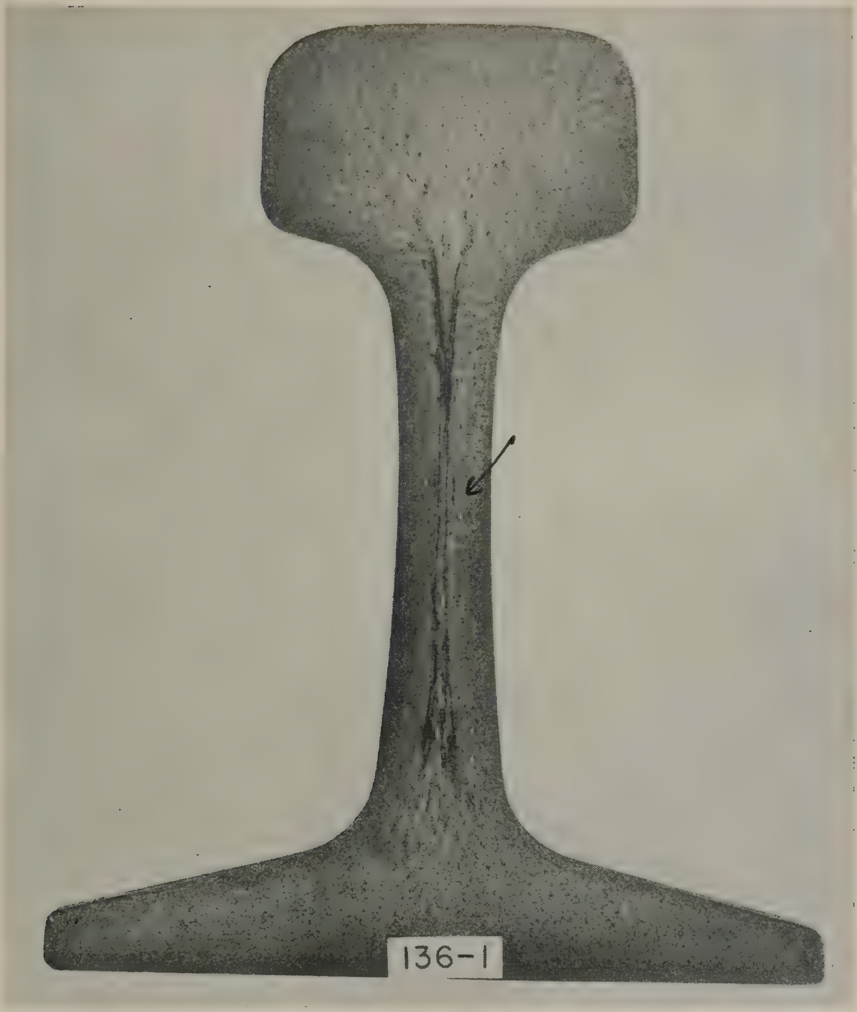


Fig. 1—Macrograph of a cross section adjacent to the weld showing the segregation that caused the weld failure in rail 61463-A-2.

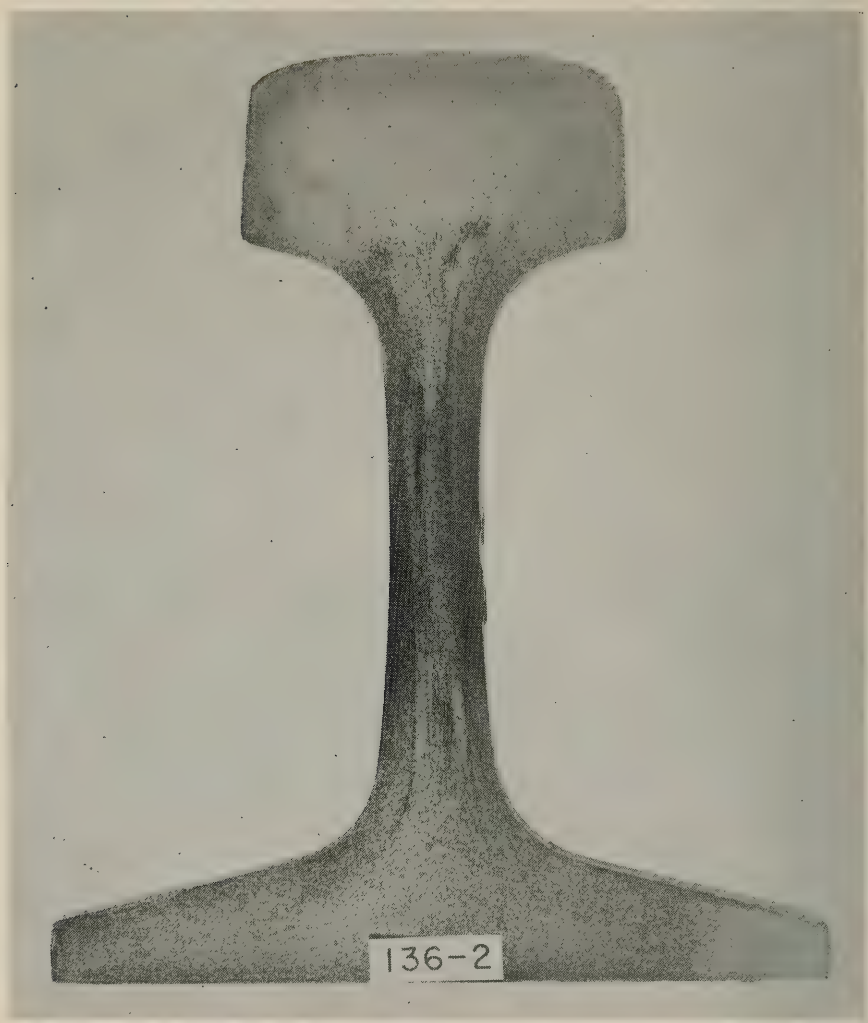


Fig. 2—Macrograph of a cross section adjacent to the weld showing the pipe that caused the weld failure in rail 39209-A-29.

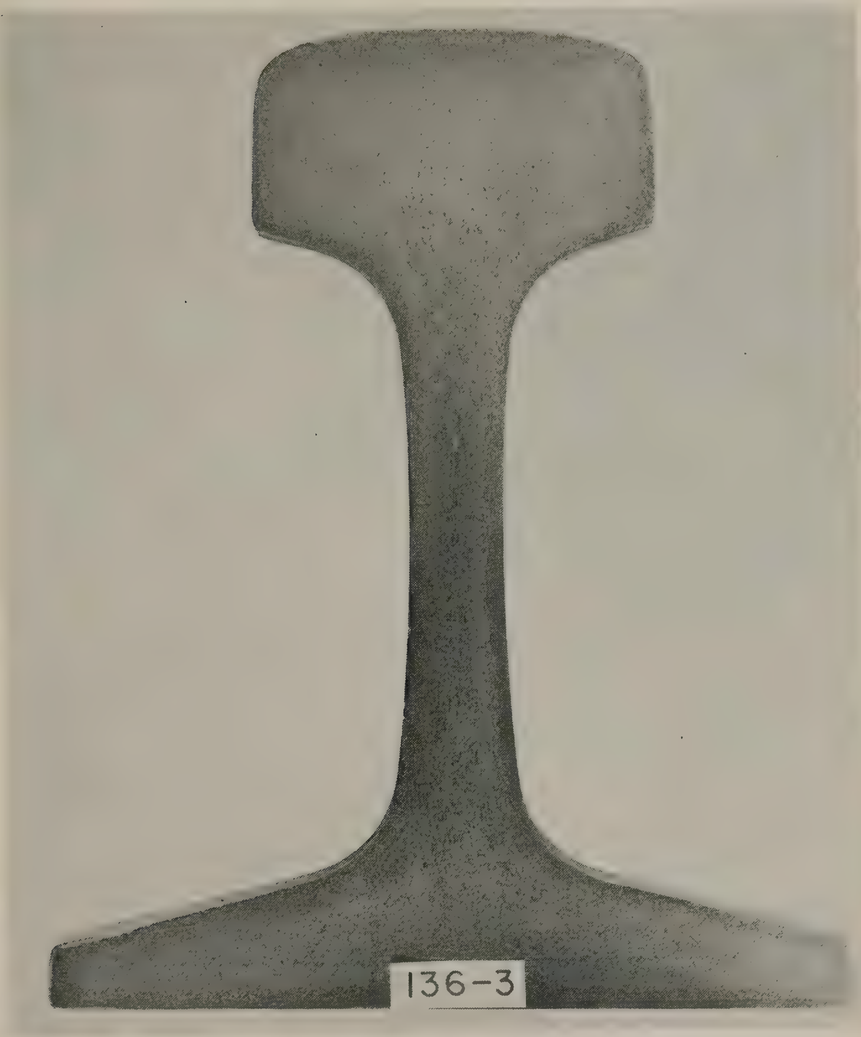


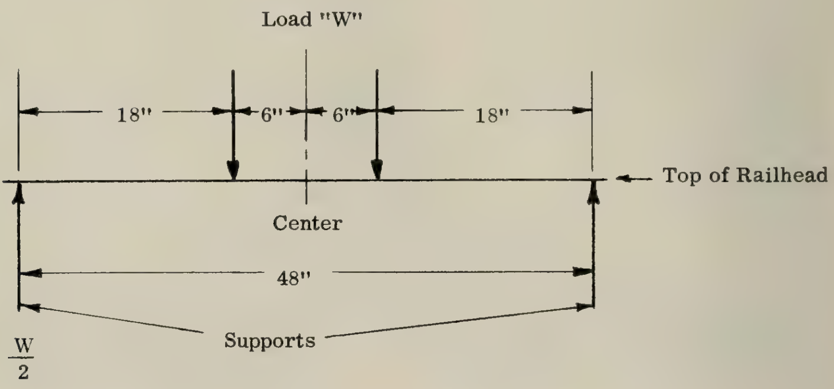
Fig. 3—Macrograph of a cross section adjacent to the weld showing the fish tail that caused the weld failure in rail 37150–C–14.

Part 3—Results of Rolling-Load and Slow-Bend Tests of Butt-Welded Rail Joints

During the period from August 1, 1963, to October 1, 1964, rolling-load and slow-bend test results were obtained at the AAR Research Center on rail joints welded by various methods, including submerged arc, the thermit process, and the oxyacetylene pressure process with abrasive-wheel-cut weld faces and with variations in upset pressure and Btu input. In these investigations there were also included welds with magnaflux and ultrasonic indications of defects. The results are shown in Tables 1 and 2.

In Table 2 a column has been added giving the modulus of rupture, the derivation of which is shown in Fig. 1. The slow-bend test is performed with the rail head up. The supports for the base are 48 in apart. The rail is loaded at two points, one on each side of and 6 in from the center of the weld. The load W is applied at these two points which results in a reaction at the support equal to $W/2$ with a moment arm of 18 in. The bending moment then is $W \times 9$ in-lb, and the modulus of rupture in pounds per square inch equals $W \times 9$ divided by the section modulus of the rail base.

The investigations were requested by the railroads shown in Tables 1 and 2. It should be noted that the results, particularly of the submerged arc process, are representative of initial work on developments that need considerable further refinement. The results on the thermit welds are representative of the results obtained in previous tests of such welds, with the exception of those made by the Southern Railway, which for the first time show results meeting the standards established by tests of oxyacetylene pressure butt welds and flash butt welds. The investigations of the welds with the magnaflux and ultrasonic indications indicate the lack of uniformity that exists in judging these indications at the inspection stations.



$$\frac{9\ \text{W}}{\text{Section Modulus of the Rail Base}} = \text{Modulus of Rupture}$$

Fig. 1—Diagram of the loading arrangement for the slow bend test and formula for deriving the modulus of rupture.

TABLE 1
ROLLING LOAD TEST RESULTS OF BUTT WELDED RAIL JOINTS
AAR Research Center, (August 1, 1963 to October 1, 1964)

Specimen No.	Rail Section Lb./Yd.	Type of Weld	Supplied or Welded by	Rolling Load Machine Stroke	Wheel Load (Lbs.)	Number of Cycles	Remarks
133 A	127 lb Dudley	Submerged arc	NYC RR	12 in	54,400	311,000	Rail broke
133 B	"	"	"	"	"	1,018,800	"
133 C	"	"	"	33 in	55,500	263,600	Rail cracked across base
133 D	"	"	"	"	"	365,800	Base cracked
134	136 lb	Thermit weld	SP Co.	12 in	60,000	782,200	Rail broke
141 A	136 lb CF&I	Flash butt weld with magnaflux indications	"	"	59,500	2,000,000	No failure
141 B	"	"	"	"	"	1,289,800	Rail broke
141 E	"	"	"	"	"	1,958,900	"
141 F	"	"	"	"	"	2,021,900	"
141 N-156	113 lb HF (Used)	Flash butt weld. Gasoline torch cut and welded	"	"	47,000	2,000,000	No failure
141 O-156	"	"	"	"	"	"	"
142 A	136 lb RE	Flash butt weld made from "D&B" rails of 32nd ingot	AT&SF RR	"	60,000	1,829,700	Rail broke
142 B	"	"	"	"	"	2,000,000	No failure
146 A-1 A	115 lb RE	Oxyacetylene pressure butt weld. Rail ends cut with an abrasive wheel (wet)	IC RR	"	48,000	"	"
146 B-1 B	"	"	"	"	"	"	"
146 G-2 A	"	"	"	"	"	"	"
146 I-2 C	"	"	"	"	"	"	"
151	115 lb RE	Flash butt weld with an ultrasonic indication	MP RR	"	"	"	"
152 A	136 lb	Thermit weld	SP Co.	"	59,500	416,800	Rail broke
152 B	"	"	"	"	"	582,900	"
158 C	100 lb RE	Thermit weld.- German Electro-Therm process	Southern RR	"	40,000	2,000,000	No failure
158 E	"	"	"	"	"	"	"
158 J	"	"	"	33 in	"	1,756,600	Test still in progress
161 A	115 lb RE	Oxyacetylene pressure butt weld. High heat and high pressure	SAL RR	12 in	48,000	2,003,700	No failure
161 B	"	"	"	"	"	2,000,000	"
165	132 lb RE	Thermit weld	Exomet, Inc.	"	57,500	610,400	Test still in progress

TABLE 2

SLOW BEND TEST RESULTS OF BUTT WELDED RAIL JOINTS

AAR Research Center, (August 1, 1963 to October 1, 1964)

Spec. No.	Rail Section Lb./Yd.	Type of Weld	Railroad	Max. Load Lb.	Max. Defl. In.	Energy for Frac. Ft. Lb.	Modulus of Rupture P.S.I.	Remarks
133 G	127 lb Dudley	Submerged arc	NYC	227,000	.5	5,900	73,977	Porosity in base
133 H	"	"	"	284,000	.8	13,800	96,818	"
1 A	115 lb RE	Oxyacetylene pressure butt weld	IC	293,000	1.1	19,600	118,954	No fusion in base
1 B	"	" "	"	288,000	1.2	20,400	117,818	"
2 A	"	" "	"	236,000	.6	7,900	96,181	Fine grain structure in weld fracture
2 B	"	" "	"	339,000	2.2	47,083	138,681	Broke outside weld
3 A	136 lb CF&I	Flash butt weld with magnaflux indications	SP	283,000	.5	7,900	90,000	Broke due to fish tail
3 B	"	" "	"	247,000	.4	5,000	78,551	Broke in weld
3 C	"	" "	"	287,000	.6	12,000	91,272	"
3 D	"	" "	"	244,000	.4	5,000	77,597	"
4 A	100 lb RE	Thermit weld	Southern	200,000	.7	8,333	101,123	"
4 B	"	"	"	216,000	1.0	12,500	109,214	Broke in weld in base
161 C	115 lb RE	Oxyacetylene pressure butt weld	SAL	402,000	5.0	130,416	164,454	Did not break
161 D	"	" "	"	411,000	5.0	133,766	168,133	Broke adjacent to the weld

Report on Assignment 2

Laying

O. E. Fort (chairman, subcommittee), W. D. Almy, E. J. Brown, E. M. Cummings, E. Eskengren, E. M. Hodges, T. B. Hutcheson, H. W. Jenkins, W. J. Jones, A. B. Lewis, L. W. Neville, Jr., M. S. Reid, C. W. Wagner, E. H. Waring.

Your committee's report on Assignment 2 is presented in two parts. Part 1 is a progress report on the development of recommended practices for the laying of continuous welded rail. Part 2 provides statistics on the amount of continuous welded rail laid annually since 1933.

Part 1—Development of Recommended Practices for Laying Continuous Welded Rail

Your committee has accumulated considerable data and has made some analysis of the problems. It is expected that the study will be completed and recommended practices for laying continuous welded rail drawn up and offered for adoption and publication in the Manual next year.

Part 2—Statistics

TRACK MILES OF CONTINUOUS WELDED RAIL LAID, BY YEARS, 1933–1964

1933	0.16	1953			80.00
1934	0.95	1954			87.00
1935	4.06				
1936	1.52				
1937	31.23		*Oxy-acetylene*	*Electric Flash*	*Total*
1939	6.04	1955	194.50	72	266.50
1942	5.48	1956	372.33	89.10	461.43
1943	6.29	1957	390.47	159.65	550.12
1944	12.88	1958	148.11	312.13	460.24
1945	4.81	1959	378.65	691.92	1070.57
1946	3.91	1960	299.42	961.20	1260.62
1947	18.70	1961	94.13	926.50	1020.63
1948	29.93	1962	310.59	1183.34	1493.93
1949	33.05	1963	497.52	1360.48	1858.00
1950	50.25	1964	586.76	1796.74	2383.50
1951	37.25				
1952	40.00				11279.05

BREAK-DOWN OF CONTINUOUS WELDED RAIL LAID IN 1964—TRACK MILES

	Oxyacetylene		*Electric Flash*		*Totals*
	New	*Second-Hand*	*New*	*Second-Hand*	
Main Track	329.03	255.39	950.89	809.01	2344.32
Yard Tracks	---	2.34	---	36.84	39.18
	329.03	257.73	950.89	845.85	2383.50

In addition to the foregoing, one road reports laying the following amounts of welded rail (lengths under 400 ft): New rail fabricated by the electric-flash process, 6.56 miles; secondhand rail fabricated by the electric-flash process, 54.80 miles.

Report on Assignment 3

Fastenings

R. E. Frame (chairman, subcommittee), M. P. Anderson, J. E. Campbell, J. D. Case, O. E. Fort, R. G. Garland, B. J. Gordon, J. A. MacNab, W. J. Jones, C. R. Merriman, C. E. Morgan, R. P. Roden, C. W. Wagner.

Last year your committee reported on its study of rail anchorage patterns for continuous welded rail. It was concluded that current practice does not support a revision of the rail anchorage pattern now appearing on page 5–5–4.2 of the Manual.

Your committee has advice that some difficulties are being experienced with continuous welded rail. Replying to a questionnaire circulated among committee members, six roads reported trouble with line kinks, nine with pull-aparts, and six reported having cut and adjusted rail after it had been laid.

Your committee recognizes the need for supplementing our present knowledge of anchorage for continuous welded rail but is unable to propose any changes until more scientific data are available from field tests, including installations with different numbers of ties anchored, different types of ballast and determinations of proper temperature ranges for laying or adjusting continuous welded rail. This subject will receive further study.

Report on Assignment 4

Maintenance

J. R. Rymer (chairman, subcommittee), W. D. Almy, E. M. Cummings, R. E. Dove, E. Eskengren, R. G. Garland, B. J. Gordon, E. M. Hodges, J. L. Hodgkinson, H. W. Jenkins, W. J. Jones, C. P. Martini, A. S. McRae, C. R. Merriman, L. W. Neville, Jr., F. L. Rees, C. W. Wagner, E. H. Waring, C. E. Weller.

Your committee has completed its review of the tentative new ballast sections and ballast quantity graphs appearing in Bulletin 584, Vol. 65, page 508, in order to determine if any change should be made in these sections to accommodate continuous welded rail.

Your committee recommends that the following revisions be made in tentative new ballast sections:

(1) For CWR a full ballast section should be provided, i.e., to the tops of the ties instead of 1 in below.

(2) Six-inch shoulder berms should be provided beyond the ends of the ties both on tangent track and the high side of curved track. Different ballast sections for tangents and curves are not compatible with mechanized ballast distributing operations. It is the consensus that the additional ballast in excess of 6 in beyond the tie ends is of little or no benefit in preventing alignment irregularities or buckled track.

Report on Assignment 5

Economics

T. C. Shedd (chairman, subcommittee), W. E. Chapman, L. S. Crane, R. E. Dove, C. R. Harrell, W. J. Jones, B. J. Johnson, K. R. Kilburn, J. A. MacNab, C. P. Martini, S. H. Poore, F. L. Rees, C. W. Wagner.

As part of its studies on the economics of continuous welded rail, Subcommittee 5 was asked to make an analysis of the cost of transporting welded rail strings using various types of single- and multiple-tier trains.

It might seem obvious that multiple-tier trains offer more economy than single-tier trains. However, few definite figures have been published on this subject, and it was felt that if meaningful data could be obtained they would be useful to all railroads who may need to consider this matter.

The study is being progressed in two parts: (a) Collection of data from individual railroads through a questionnaire form; and (b) detailed analysis of the economic factors involved in the transportation of welded rail strings.

The committee expects to conclude the data collection and economic analysis and to submit its report next year.

Report on Assignment 6

Welding Secondhand Rail

J. B. Beaver (chairman, subcommittee), M. P. Anderson, S. H. Barlow, J. D. Case, W. E. Chapman, C. O. Conatser, H. C. Fox, B. J. Johnson, W. J. Jones, M. S. Reid, R. P. Roden, C. W. Wagner.

The use of secondhand rail in the continuous welded rail programs of many railroads is increasing. Some railroads weld as much or more secondhand rail than new. This is true because of the greater availability of secondhand rail and the economy to be realized through its use.

The abandonment of certain lines and track retirement in multiple track territory in connection with CTC installation, make rail available that is suitable for welding and reuse in main track. It is desirable to use control-cooled rail for welding.

The economies to be realized are peculiar to the individual railroad, varying with method of recovery, cost of handling through the reclamation plant and class of rail available.

Proper handling of good secondhand rail can produce welded rail with a service life practically equal to the life of new jointed rail in its first location. This is true because most rail is released from its first location because of joint conditions rather than the condition of the rail as a whole. A basic requirement is that the released rail be picked up in the field without being dismantled, or dismantled and marked for identification in order that it may be welded in the original sequence. It is desirable to weld rail in the original sequence in order to match rail of the same head wear.

The preparation of secondhand rail for welding and returning it to the track from which it was removed, or to a track of equal traffic density and speed, involve the following recommended operations or procedure.

(a) Handling the rail in such a manner as to keep it in the original sequence.

(b) Plant testing by the ultrasonic, or equal, method. This is very positive and practical as the rail can be passed through the stationary testing equipment at a uniform rate of speed. This permits close adjustment.

(c) Vertical and horizontal straightening of the rail prior to cropping permits the rail to be straightened at least to the point where it is to be cropped. Having rail ends that are straight both vertically and horizontally improves the quality and quantity of welds.

(d) Excessive overflow metal on the gage and field sides of rail has been troublesome in welding secondhand rail. Experiments are now underway to develop a satisfactory method of removing the metal by use of an abrasive saw and restoring the contour of the head by grinding. Laboratory examination of rails sawed to date indicates that this can be done successfully. When this process or operation is perfected, much additional rail can be upgraded and welded.

(e) The repair or building up of wheel burns is being successfully accomplished. This permits rail having wheel burns to retain its proper place in the sequence of rail being welded. This is an important factor in the conservation of rail.

(f) Some secondhand rail has slight surface irregularities produced by cold rolling. These irregularities set up vibrations that will in time affect track surface and contribute to or cause corrugations. A minimum amount of surface grinding immediately after laying and surfacing will add to the life of rail and track surface, thereby producing even greater economy.

The cost of unloading, dismantling, straightening and cropping the rail, repairing engine burns and placing the rail on racks to be fed to the welding machine is realistic. Records kept over a period of four years by one railroad show the operation to be very economical in relation to the benefits to be realized.

The loss of rail involved in cropping and welding secondhand rail varies from 12 to 15 percent. Where it is desired to improve rail conditions on a line and not increase the rail section, one train load of new rail can be laid. The rail released can be upgraded by cropping, straightening and welding and then returned to the track. This process can be repeated until the train of rail is exhausted, and can produce as much as 6.5 miles of continuous welded rail for each mile of new rail used. The economy to be realized as well as the more realistic use of secondhand rail is very evident.

The preparation or upgrading of secondhand rail for welding should conform to the refinement required where the rail is to be laid. This varies from placement in high-speed main track to the body track of yards.

The use of secondhand rail in continuous-welded-rail programs will permit the use of welded rail by railroads which are unable to purchase a sufficient amount of new rail to generate a realistic program.

Realistic and practical handling of a program of welding secondhand rail will answer some of the problems imposed by the higher center of gravity and the increased tonnage handled by the new equipment being introduced by and on most railroads.

Report of Committee 1—Roadway and Ballast

L. J. Deno, *Chairman*
C. E. Webb,
Vice Chairman
J. S. Felton, *Secretary*
F. N. Beighley
W. P. Eshbaugh
G. W. Becker
G. D. Mayor
A. J. Wegmann
G. F. Nigh
K. W. Bradley
P. G. Martin
R. D. Baldwin
T. W. Creighton

W. T. Adams
C. W. Bailey
A. S. Barr
H. E. Bartlett
E. W. Bauman
R. H. Beeder
C. R. Bergman
D. L. Bloem
R. J. Bruce
J. G. Campbell
R. E. Clemons
D. H. Cook
I. P. Cook
M. W. Cox
B. H. Crosland
A. P. Crosley (E)
H. F. Davenport
G. W. Deblin
J. W. DeMoyer
W. M. Dowdy
G. E. Ellis
J. B. Farris
J. E. Gray
M. B. Hansen
G. B. Harris
T. J. Hernandez
F. W. Hillman (E)
H. O. Ireland
H. G. Johnson
R. J. Kemper
H. W. Legro (E)

A. E. Lewis
R. R. Manion
A. Manson
W. C. McCormick
Paul McKay (E)
H. E. Moore
W. G. Murphy
J. E. Newby
R. W. Orr
S. J. Owens
F. S. Patton
G. W. Payne (E)
F. L. Peckover
S. R. Pettit
L. G. Reichert
H. E. Richards
N. B. Roberts
E. L. Robinson, Jr.
R. W. Scott
G. E. Shaw
W. M. Snow
T. S. Stone
S. W. Sweet
J. P. Taylor
W. O. Treischman
S. S. Vinton
J. B. Wackenhut
R. D. White
E. L. Woods
D. H. Yazell
Committee.

(E) Member Emeritus.
Those whose names are set in bold-face type constitute the Engineering Division, AAR, Committee 1.

To the American Railway Engineering Association:

Your committee reports on the following subjects:

1. Revision of Manual.

   Brief progress statement recommending adoption of the revisions to the Manual set forth in the reports on Assignments 3 and 10 .... page 523

2. Physical properties of earth materials:

   (a) Roadbed. Load capacity. Relation to ballast. Allowable pressures. No report.

   (b) Structural foundation beds, collaborating with Committees 6 and 8. No report.

3. Natural waterways: Prevention of erosion

   Part 1—Manual Recommendations, submitted for adoption .... page 523

   Part 2—Use of Soil-Cement Construction for Bank Protection on Levees and Embankment, submitted as information .... page 532

4. Drainage and Culverts:

   (a) Performance of filter materials in subdrains.
   No report.

5. Specifications for pipelines for conveying flammable and non-flammable substances, collaborating with Committees 15 and 20.

   Progress report, submitted as information .... page 536

6. Roadway: Formation and protection

   Proposed revised Specification for the Formation of the Roadway, submitted as information prior to submitting for adoption in 1966 .... page 537

   (a) Roadbed stabilization.

   Part 1—Soil Stabilization by Chemicals, submitted as information .. page 547

   Part 2—Effect of Irrigation System on Railroad Embankment on Northern Pacific in Vicinity of Mesa, Wash., submitted as information .... page 550

   (b) Slope protection.
   Revision of Manual material in progress, but no report.

   (c) Special treatments for subgrade improvement.
   Study in progress, but no report.

   (d) Hydraulic fills, collaborating with Committee 25.
   Draft of proposed Manual material has been prepared and submitted to Committee 25 for consideration.

7. Tunnels:

   Revised specifications have been drafted and submitted to collaborating committees for consideration.

   (a) Ventilation; changes necessary for operation of diesel power.
   Study in progress, but no report.

   (b) Clearance; methods used to increase, collaborating with Committee 28.
   Study in progress, but no report.

   (c) Methods of open cutting.
   Report on excavation of a through cut to replace Messiter Tunnel on the Canadian National Railways, submitted as information .... page 559

8. Fences:

   (a) Metal fence to check drifting snow and sand.
   Revision of Manual material in progress, but no report.

9. Roadway signs:

   (a) Reflectorized and luminous roadway signs, collaborating with Committees 5 and 9, and with Communication and Signal Section, AAR.
   Research has been discontinued temporarily because of the curtailment of research funds.

   (b) Shop layout for production of roadway signs.
   Report showing typical sign-shop layout, submitted as information .. page 566

10. Ballast:

Manual recommendations, submitted for adoption .... page 569

(a) Tests.
No report.

(b) Special types of ballast.
Progress report on asphalt-treated ballast, submitted as information . page 569

11. Chemical control of vegetation, collaborating with Communication and Signal Section, AAR.

Part 1—Report on weed control seminar held in Chicago, Illinois, October 6–7, 1964, submitted as information .... page 576

Part 2—Report on helicopter spraying on railroad right-of-way, submitted as information .... page 576

THE COMMITTEE ON ROADWAY AND BALLAST,
L. J. DENO, *Chairman.*

AREA Bulletin 591, February 1965.

Report on Assignment 1

Revision of Manual

F. N. Beighley (chairman, subcommittee), R. D. Baldwin, G. W. Becker, K. W. Bradley, T. W. Creighton, W. M. Dowdy, W. P. Eshbaugh, P. G. Martin, G. F. Nigh, A. J. Wegmann, D. H Yazell.

Your committee recommends the adoption of the revisions to the Manual as set forth in the reports on Assignments 3 and 10.

Report on Assignment 3

Natural Waterways: Prevention of Erosion

G. W. Becker (chairman, subcommittee), G. W. Deblin, H. E. Moore, S. S. Vinton.

Part 1—Manual Recommendations

Your committee submits for adoption the following recommendations with respect to Part 1, Chapter 1, of the Manual:

Delete the material on Construction and Protection of Roadbed Across Reservoir Areas now appearing on Manual pages 1–1–36.1 to 1–1–36.6, incl., substituting therefor the following revised version.

CONSTRUCTION AND PROTECTION OF ROADBED ACROSS RESERVOIR AREAS

The construction and protection of roadbed across reservoir areas present many problems that are not encountered in normal roadbed constuction. Analysis of these problems can best be made by subdividing the subject into three sections, as follows:

A. Determination of Wave Heights
B. Construction of Embankment and Roadbed
C. Construction of Embankment Protection

The term "reservoir area" as used in this report also includes lakes, natural and artificial river pools, and other inland waters on which waves may be generated.

A. DETERMINATION OF WAVE HEIGHTS

Knowledge relating to wind velocities over land and over water, and wave heights on inland reservoirs, has increased in recent years as a result of studies made by the Coastal Research Center (formerly known as the Beach Erosion Board), and by the Corps of Engineers at Fort Peck Reservoir in northeast Montana, Denison Reservoir on the Oklahoma–Texas state line, and Lake Okeechobee in Southern Florida.

These studies resulted in the publication of Technical Memorandum No. 132, "Waves in Inland Reservoirs"[1] by the Beach Erosion Board, essentially the same information having appeared in ASCE Proceedings Paper No. 3138 (May 1962), corrected May 1963.

The methods subsequently described are adapted from Technical Memorandum No. 132, and are adequate for ordinary wave problems. For more extensive or complicated situations, the designer should refer to Technical Memorandum No. 132, or to Technical Report No. 4, "Shore Protection Planning and Design"[2] by the Beach Erosion Board, or to other references listed in these publications.

Elements affecting the determination of wave heights may be listed as follows:

1. Effective Fetch (*F*)

Fetch, or the distance over which the wind blows, was originally designated as the greatest straight-line distance across open water. Subsequent studies have shown that the shape of an open-water area affects the effective fetch.

For a given size and shape of water area, effective fetch is determined by laying out seven radials at 6-deg intervals on each side of a central line through the point under study, extending them to their point of intersection with the shore line. The scaled component of each radial's projection on the central radial is then multiplied by the cosine of its angle with the central radial. The sum of these values divided by the sum of the cosines determines the effective fetch (*F*) for that location. An example of this calculation is shown in Fig. 4.

2. Wind Velocity (*U*)

Wind velocities over water are higher than over land, and although individual observed values may vary considerably, average values for this relationship have been observed as follows:

TABLE 1—WIND RELATIONSHIP, LAND TO WATER

Fetch, in Miles	0.5	1	2	4	6 and over
Wind ratio $\frac{U_{water}}{U_{land}}$	1.08	1.13	1.21	1.28	1.31

Thus, a wind having a velocity of 40 mph over land could be expected to attain a velocity of 40 × 1.28, or 51 mph over water if the effective fetch were 4 miles.

3. Minimum Wind Duration (t_d)

With wind velocity assumed to be constant over a particular fetch, the height of waves being generated will progressively increase with time up to a maximum value for that velocity. The minimum wind duration in minutes for producing this maximum wave can be determined from the dashed lines in Fig. 1, given the wind velocity in miles per hour and the effective fetch in miles.

4. Significant Wave Height (H_s)

Although successive waves in a group will vary in height, the significant wave height is defined as the average of the highest one-third of the waves being generated, measured from trough to crest, and is determined from the solid diagonal lines in Fig. 1. Since wind-generated waves on a large body of water are not uniform in height, the significant wave height thus determined will be exceeded approximately 13 percent of the time.

5. Specific, or Design, Wave Height (H_o)

Wave studies have shown that wind-generated waves are not uniform in height, but consist of groups of waves with varying heights. Studies of inland reservoirs show the following relationship between the significant wave height (H_s) which is exceeded 13 percent of the time, and a selected specific wave height (H_o) exceeded less frequently:

TABLE 2—WAVE HEIGHT DISTRIBUTIONS

Ratio of Specific Wage Height H_o to Significant Wave Height H_s, (H_o/H_s) (1)	Percent of Waves Exceeding Specific Wave Height H_o (2)
1.00	13
1.07	10
1.27	4
1.40	2
1.60	1
1.67	0.4

Having determined the significant wave height from Fig. 1, a design wave of acceptable frequency of occurrence is computed by multiplying H_s by the corresponding ratio value in Table 2. A ratio of 1.87 is frequently used for the so-called maximum wave, but over extended periods of observation, individual waves may even exceed this value.

6. Wave Period (T)

The significant wave period represents the average interval in seconds between successive waves, and is determined from Fig. 2. The resulting wave period is also applicable to the higher waves in the group.

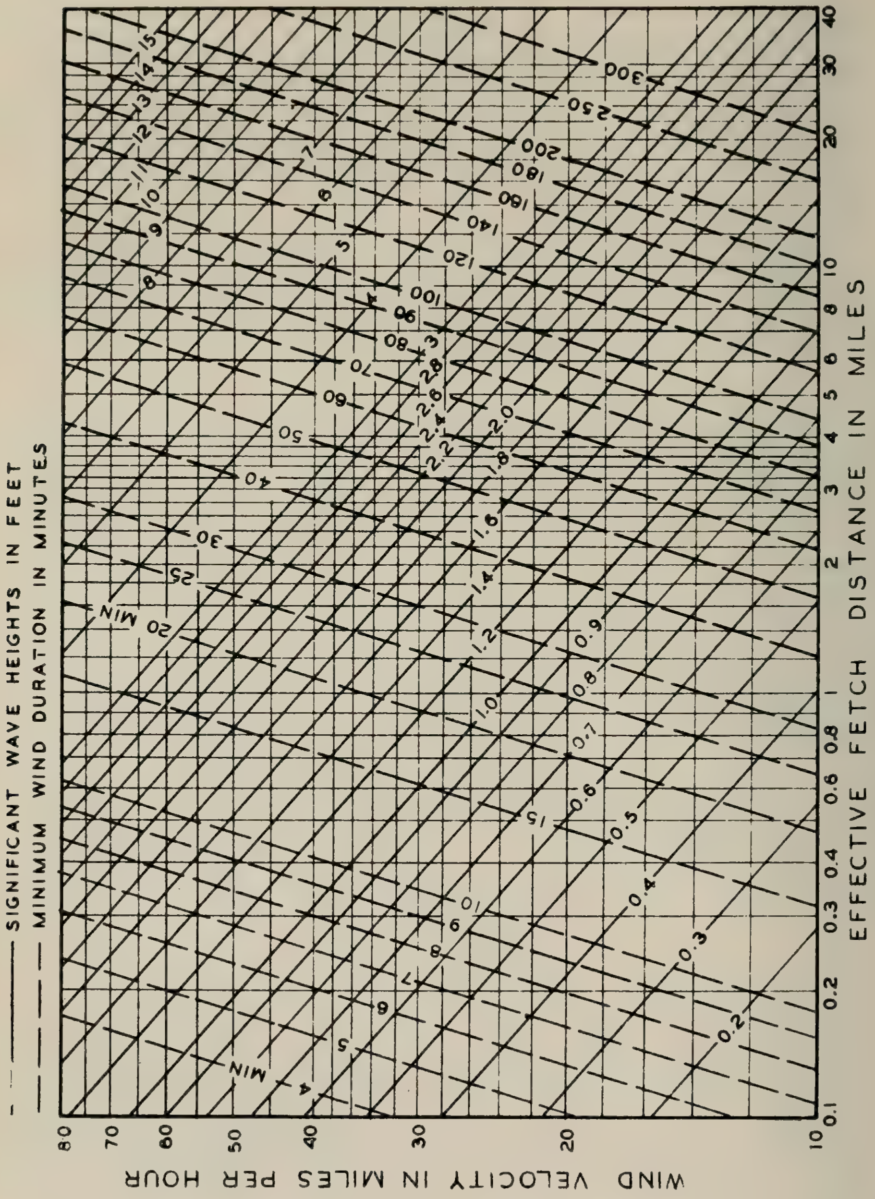


Fig. 1—Wave heights and minimum wind durations.

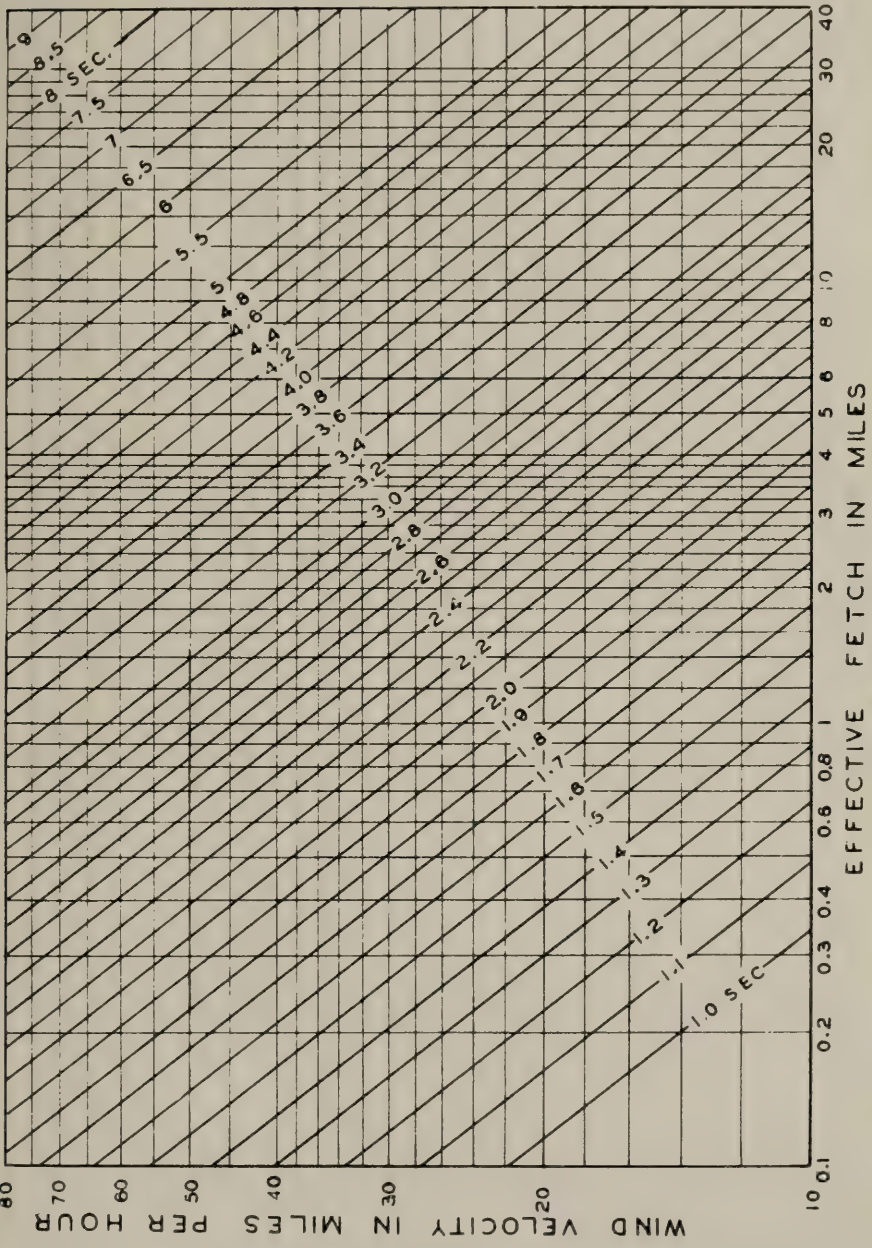


Fig. 2—Wave periods.

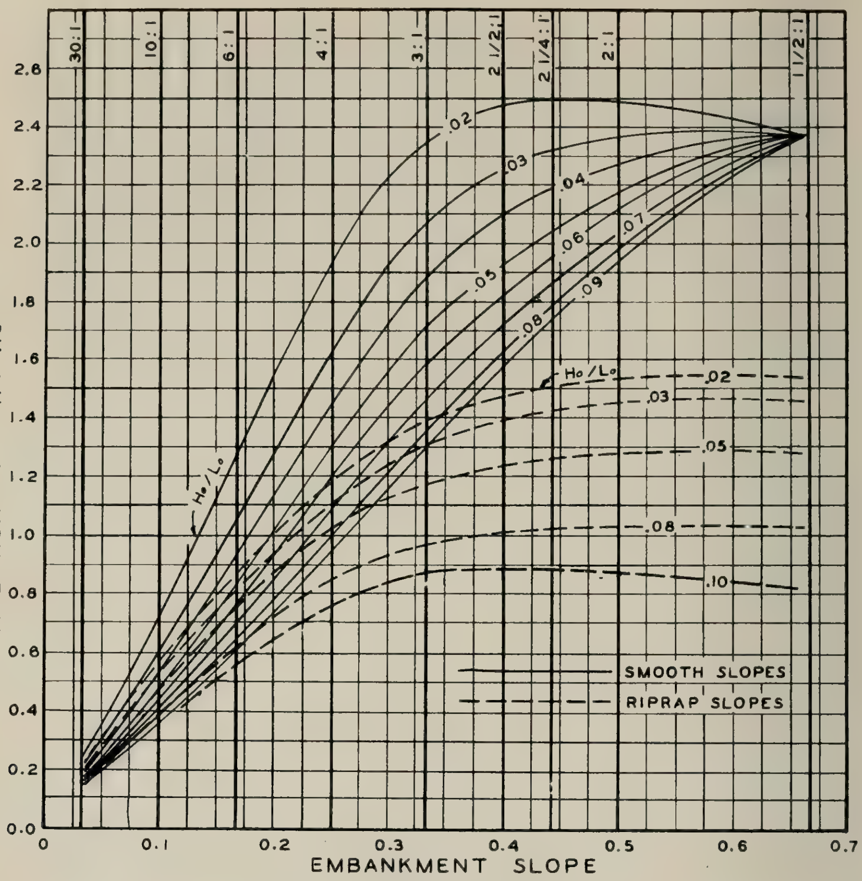


Fig. 3—Wave run-up ratios.

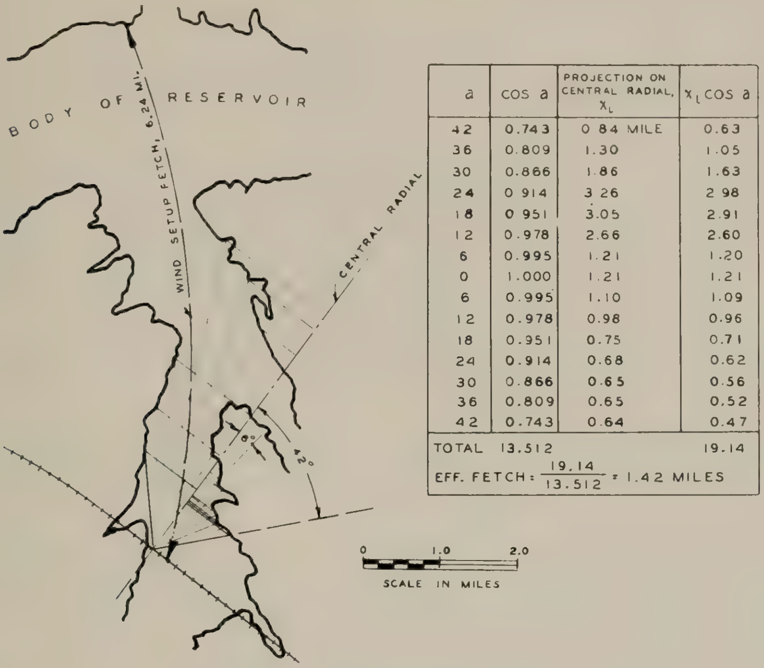
7. Wave Length (*L*)

The wave length (*L*) is measured from crest to crest of waves in feet, and is equal to 5.12 T^2. However, wave heights and other characteristics are limited by the depth of water in which they are generated if that depth is less than approximately one-half the wave length. Observations at Lake Okeechobee[3] indicated that waves were limited to a maximum significant wave height of approximately 0.6 of the average depth of water in the generating area, regardless of duration and velocity of wind.

For determining the characteristics of shallow-water-generated waves, reference may be made to the previously mentioned Technical Memorandum No. 132, or Technical Report No. 4.

8. Set-up, or Wind Tide (*S*)

An enclosed body of water over which a wind is blowing tends to pile up at higher elevations at the leeward end, and on long fetches this set-up may assume importance



a	cos a	PROJECTION ON CENTRAL RADIAL, X_L	X_L cos a
42	0.743	0 84 MILE	0.63
36	0.809	1.30	1.05
30	0.866	1.86	1.63
24	0 914	3 26	2 98
18	0 951	3.05	2.91
12	0.978	2.66	2.60
6	0.995	1.21	1.20
0	1.000	1.21	1.21
6	0.995	1.10	1.09
12	0.978	0.98	0.96
18	0.951	0.75	0.71
24	0.914	0.68	0.62
30	0.866	0.65	0.56
36	0.809	0.65	0.52
42	0.743	0.64	0.47
TOTAL	13.512		19.14

$$\text{EFF. FETCH} = \frac{19.14}{13.512} = 1.42 \text{ MILES}$$

Fig. 4

in the design of bank protection. The increase in water level above the still-water elevation that would prevail without wind action is determined by the formula:

$$S = \frac{U^2 F}{1400 \ D}$$

where S = set-up in feet.

U = velocity of the wind in miles per hour.
F = fetch in statute miles.
D = average depth of the body of water in feet.

Fetch distance used here differs from effective fetch (F) previously described in that it may be of a curved or sweeping character, and need not move in a straight line. It can also be greater in length than the effective fetch (see Fig. 4).

9. Wave Run-up (R)

On reaching a fill a wave will run up the slope to an elevation largely dependent on the angle of slope, the roughness of the embankment, and the steepness of the wave (H_o/L_o). From Fig. 3, relative run-up on smooth or average riprap covered slopes can be determined where the embankment slope and steepness of design wave are known. Run-up (R) in feet is secured by multiplying the relative run-up thus found by the design wave height (H_o), and total run-up will then be the sum of run-up (R) and set-up (S).

B. CONSTRUCTION OF EMBANKMENT AND ROADBED

The embankment should be constructed in accordance with Specifications for the Formation of the Roadway, Part 1, this Chapter, except as modified in conformance with the following:

That portion of the embankment which will be submerged should have side slopes not steeper than 3 to 1, and no material should be used in the embankment which has a liquid limit in excess of 60 as determined in accordance with ASTM Designation D 423–61T, Standard Method of Test for Liquid Limit of Soils. Width of roadbed, side slopes, prepared ballast and sub-ballast should be in accordance with the standards of the railroad company. Factors not encountered in ordinary roadbed construction that should receive consideration include probable maximum water-surface elevation, frequency of occurrence and duration of embankment submergence, possible head on the embankment (water surface on one side higher in elevation), and drawdown effect due to the rapid release of stored water.

The probable maximum water surface elevation, together with the design wave height, wind tide and wave run-up effects will govern the elevation at which the roadbed should be constructed. In special cases the increased headwater elevation due to inflowing water may also be significant.

Frequency and duration of embankment submergence is important in determining the suitability of available embankment material and recommended slopes. An embankment that is stable under ordinary conditions may not be stable when saturated because of long submergence.

The permeability of the soil to be used in the embankment should be considered in connection with the probable maximum rate of drawdown in the case of reservoirs. Embankments composed of impervious materials that are stable when dry, or even when saturated, may fail if the water surface is lowered rapidly while the embankment is saturated. Pervious free-draining soils are not as susceptible to failure from this cause as are impervious soils.

C. CONSTRUCTION OF EMBANKMENT PROTECTION

1. General

Experience has shown that in the majority of cases, dumped riprap furnishes the best type of protection at the lowest ultimate cost. Its effectiveness depends on the quality of the rock and its weight or size, thickness of the layer, shape of the individual stones, slope of the embankment, and stability of the base or filter on which it is placed. Usually, the availability of riprap sources determines to some extent the quality and size of stone used for slope protection.

2. Weight and Thickness of Riprap

Formulas for rock protection of slopes have, until recent years, been more applicable to coastal installations. Requirements for inland bodies of water have been found to require somewhat different standards of design. One extremely useful set of formulas appears in the Corps of Engineers' Manual, EM 1110–2–2300 (1 April 1959), and is substantially as follows:

$$W_{avg} = \frac{62.4\ S\ H_o^2}{1.82\ (S-1)^3 \cot a}$$

$$W_{max} = 4 \times W_{avg}$$

$$W_{min} = \frac{W_{avg}}{8}$$

$$\text{Minimum Thickness in Inches} = 18 \sqrt[3]{\frac{W_{avg}}{62.4\ S}}$$

where W = weight of individual stones in pounds
S = specific gravity of the rock
H_o = design wave height in feet
a = the angle of slope with the horizontal

Gradation of weights of stone should fall within the following classifications: At least 45 percent shall be greater than W_{avg} with not more than 10 percent greater than W_{max} or 10 percent less than W_{min}.

It should be noted that riprap selected by the use of these formulas is suitable for protecting embankments against wave action in normal circumstances. Special consideration should be given to specific needs for protection of foundations from scour, or at locations where riprap may be displaced by ice action.

3. Minimum Requirements

The protective covering should extend from the natural ground surface at the toe of slope to an elevation at least 2.0 ft above the height of total run-up as determined in Sec. A, or 4.0 ft above still-water elevation, whichever is greater. Where the natural ground does not provide adequate support, or where scour is possible, riprap should be extended below the toe of slope by trenching to the required depth.

The thickness of riprap cover should satisfy design requirements of Sec. C, Art. 2, but should not be less than 18 in thick.

4. Filter Blanket

A bedding layer or filter blanket should be provided underneath riprap protection when the compacted material of the underlying embankment consists of silt or fine sand. In this case there is a danger of the fill material being washed out through voids in the riprap by wave action which can result in undermining of the cover material.

The filter blanket, composed of gravel (preferably crushed), crushed rock or slag, should be not less than 6 in and not more than 12 in. in thickness, and should be placed on the embankment slope to form a backing for the riprap protection, and should be reasonably well graded within the following limits:

Sieve Size	*Percent by Weight Passing*
3″	100
1½″	40–60
No. 40	0–5

5. Littoral Currents and Refraction

Littoral current, the result of waves breaking at an angle to the shoreline, and refraction, the process by which the direction of a wave moving in shallow water at an angle to bottom contours is changed, are primarily the concern of designers of coastal shore-protection structures, and are not covered here. Reference is made to the Beach Erosion Board's Technical Report No. 4, "Shore Protection Planning and Design," for detailed information on these subjects.

SAMPLE COMPUTATION FOR DETERMINING WAVE HEIGHT AND PROTECTION NEEDS (See Fig. 4)

(1) Effective fetch (F)	1.42 miles
(2) Average wind velocity over land	40 mph
(3) Average wind velocity over water (U), $= 40 \times 1.21$ from Table 1	48 mph
(4) Minimum duration (t_d) to produce computed wave, from Fig. 1	23 min
(5) Significant wave height (H_s), from Fig. 1	2.6 ft
(6) Design wave height (H_o), exceeded by only 0.4 percent of the waves, $= H_s \times 1.67$ from Table 2	4.3 ft
(7) Wave period (T) for significant and design waves, from Fig. 2	3.0 sec
(8) Wave length (L_o) for design wave $= 5.12 \times T^2$	46.1 ft
(9) Wave steepness (H_o/L_o) $= 4.3/46.1$	0.093
(10) Set-up (S) $= \frac{U^2 F_s}{1400\, D}$, where wind tide fetch (F_s) is 6.24 miles (Fig. 4), and average depth of lake is 30 ft	0.34 ft
(11) Relative run-up ratio (R/H_o) for riprap on 2.5:1 slope, and $H_o/L_o = 0.093$, using Fig. 3	0.94
(12) Wave run-up (R), (6) × (11)	4.0 ft
(13) Total run-up, (10) plus (12)	4.3 ft
(14) Weight of rock protection, from Sec. C, Art. 2, where: $S = 2.6$ for limestone $H = 4.3$, design wave height $\cot a = 2.5$ for 2.5:1 slope	
Then: W_{avg}	162 lb
W_{max}	648 lb
W_{min}	20 lb
Minimum Thickness	18 in

BIBLIOGRAPHY

1. Beach Erosion Board, Corps of Engineers (1962), "Waves in Inland Reservoirs," Technical Memorandum No. 132.
2. Beach Erosion Board, Corps of Engineers (1954, Revised 1961), "Shore Protection Planning and Design," Technical Report No. 4.
3. Jacksonville District, Corps of Engineers (1955), "Waves and Wind Tides in Shallow Lakes and Reservoirs," Civil Works Investigation CW–167.

Part 2—Use of Soil-Cement Construction for Bank Protection on Levees and Embankments

In recent years the construction of flood-control, irrigation and recreational dams, particularly by the Bureau of Reclamation, has increased. This has led to stepped-up research on the part of the Bureau with the aim of reducing costs. Out of this research there was developed the use of soil-cement for dam facings and bank protection on levees and embankments, and for ditch and canal linings. The use of such facings has resulted in appreciable savings, particularly in the Great-Plains area where quality riprap is not available or the required haul is uneconomical. This type of protection appears to be applicable to railroads also where conditions are favorable. It has been proposed for use on several railroads where relocations and bank protection are required because of dam construction.

The following report is based on an inspection of several dams by the AAR research staff under the direction of G. M. Magee, director of engineering research, and Rockwell Smith, research engineer roadway.

In 1941, approximately, the U. S. Corps of Engineers installed a test section of soil-cement on the levees of Lake Okeechobee, Fla. In this section, the soil-cement was mixed-in-place, requiring slope travel of the mixing equipment. It has, however, performed excellently, even withstanding waves produced by winds of hurricane velocity. The next installation of which there was a record available to the research staff was constructed in 1951 on the shores of the lake formed by the Bonny dam across the Republican River near Burlington, Colo. It was mixed in place but in horizontal layers. Fig. 1 is a photo of the installation taken in 1963. The soil-cement consists of cement mixed with the sandy soil available locally. The cement portion was 12 percent by volume. This experimental section is not on the dam proper but is exposed to severe wave action and extremes of hot and cold weather. Cores taken at intervals show that the soil-cement has increased in compressive strength. The last reported strength was 2500 psi after 9½ years in place.

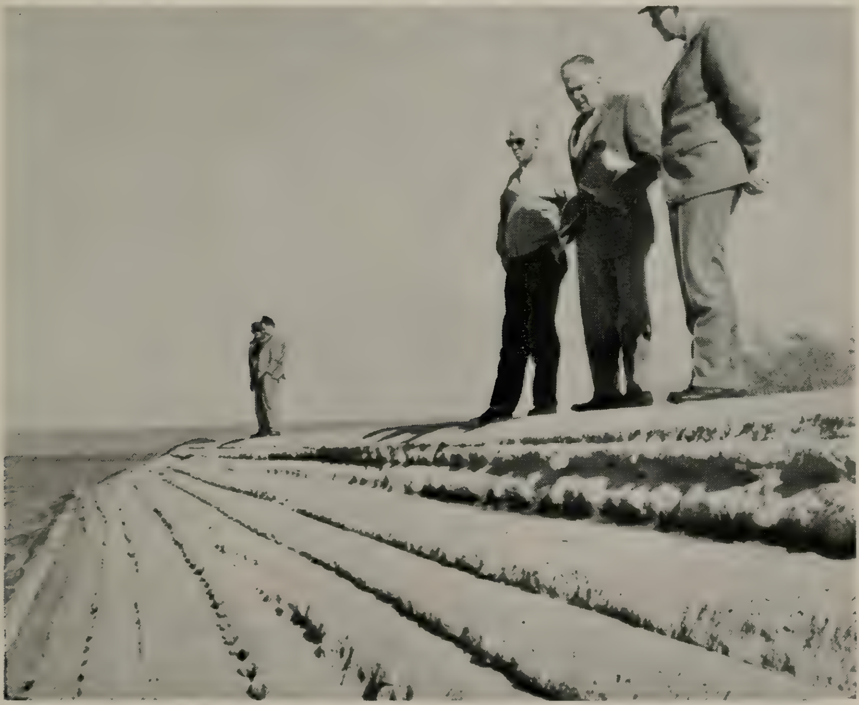


Fig. 1—Bonny Dam experimental soil-cement project. Installed 1951, photographed 1963.

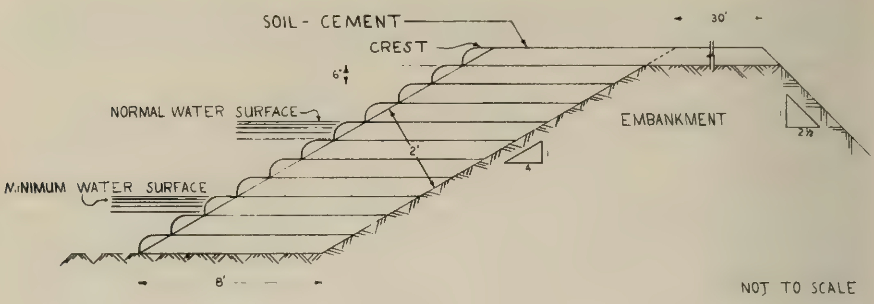


Fig. 2—Typical soil-cement dam facing.

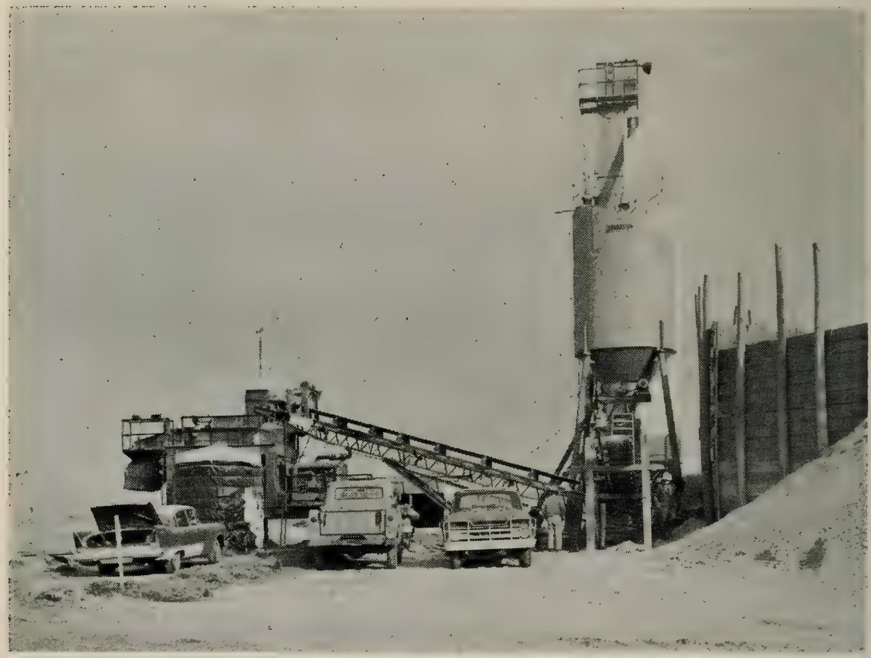


Fig. 3—Central soil-cement mixing plant, Merritt Dam.

On the basis of the results from this experimental installation the Bureau allowed soil-cement facing as an alternate to standard rip-rap in its call for bids for the construction of the Merritt Dam on the Snake River near Valentine, Neb. It was reported that the nearest stone qualifying for rip-rap was in the Black Hills of South Dakota, approximately 300 miles removed from the dam site. The contract was let on the basis of using the soil-cement facing, the low bid being approximately $489,000 less than the lowest bid based on the use of rip-rap. For the successful bidder on the project the spread between the two alternates was $643,000. Fig. 2 is a typical cross section of the soil-cement facing.

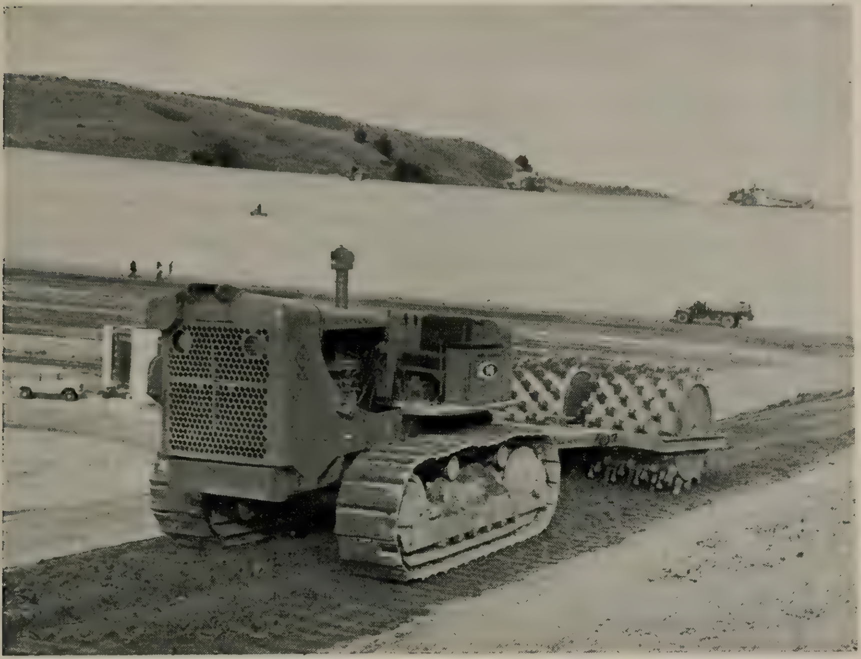


Fig. 4—Compaction of soil-cement in horizontal lifts, Merritt Dam, 1963.

For the soil-cement a sandy soil material was available locally, requiring 14 percent cement by weight. Mixing was performed in a central mixing plant as shown in Fig. 3. The mixture was hauled to the dam and placed in horizontal layers as shown in Fig. 4. Compaction was to optimum density with the required moisture to produce such density. Tests for cement content and moisture-density requirements were made in accordance with ASTM methods. Fig. 4 also shows the sheepsfoot rolling of the horizontal layers and the L-shaped section of the facing.

The Merritt dam required approximately 51,000 cu yd of soil-cement. The slope area of the facing was 76,500 sq yd. The total cost per square yard was $5.58 compared with $11.97 for rip-rap. The thickness of the facing was 2 to 3 ft normal to the slope.

The same process was used on the Cheney Dam across the Ninnescah River west of Wichita, Kans. According to Bureau reports, the savings here for soil-cement over rip-rap amounted to $700,000. The volume required was 180,000 cu yd. Normal to the slope, the depth of the soil-cement varied, depending on the amount of slope, from 2 ft 8 in to 2 ft 0 in for slopes of 2½ to 1 and 3 to 1, respectively. Costs were comparable to those of the Merritt Dam. No inspection was made of this installation. Both dams were completed in 1964.

Soil-cement facing has been applied to several other dams in the past few years. It has a definite advantage in areas where rip-rap is not economically available. It has possibilities for use by railroads also in such areas.

It is hoped that further inspections of such facings can be made after a longer service period and reported on.

Report on Assignment 5

Specifications for Pipelines for Conveying Flammable and Non-Flammable Substances

Collaborating with Committees 15 and 20

A. J. Wegmann (chairman, subcommittee), R. H. Beeder, C. R. Bergman, J. G. Campbell, G. B. Harris, F. S. Patton, M. E. Vosseller, H. L. White.

Your committee has continued its collaboration with the ASCE Committee on Pipeline Crossings of Railroads and Highways. In January 1964 this ASCE committee issued an "Interim Specification for Pipeline Crossings of Railroads and Highways," copy of which was sent to the chief engineers of all AAR Member Roads, with transmittal letter dated July 20, 1964. On September 16, 1964 an addendum letter was distributed to clarify the AREA's position in regard to the ASCE "Interim Specification."

In 1959, the Research Council of the ASCE Committee on Pipeline Crossings of Railroads and Highways was formed which initiated studies to obtain fundamental data to be used by the committee for designing casings and uncased carrier-pipe crossings. One of these studies was an extensive series of tests on 8- and 12-in nominal size uncased carrier pipes under a simulated railroad and highway crossing.

The experimental work on the 8- and 12-in pipes was conducted in 1960 by AAR Engineering Research Division personnel at the Engineering Laboratory of the AAR Research Center. This work is described in some detail in AREA Bulletin 584, February 1964, pages 492–496.

The data obtained in the tests on the 12-in pipe were analyzed by the Battelle Memorial Institute and a report on the findings was published by the ASCE. It is proposed that the data from the 8-in pipe be similarly analyzed.

The test data on the 8- and 12-in pipe gave design data on relatively small sizes of pipe. Additional test data are needed on a large-size pipe. Tests on a 24-in diameter pipe with a 0.25 in wall thickness will get underway shortly in the AAR Engineering Laboratory. With the information from the two pipes already tested and the additional data from the test on the 24-in pipe, it is hoped to develop a rational design procedure for cased and uncased gas distribution pipes under combined internal pressures and external loads.

Report on Assignment 6

Roadway: Formation and Protection

- (a) Roadbed Stabilization
- (b) Slope Protection
- (c) Special Treatments for Subgrade Improvement
- (d) Hydraulic Fills, collaborating with Committee 25

G. F. Nigh (chairman, subcommittee), H. E. Bartlett, I. P. Cook, B. H. Crosland, J. B. Farris, H. O. Ireland, A. E. Lewis, W. G. Murphy, J. E. Newby, E. W. Bauman, D. L. Bloem, J. E. Gray, G. W. Payne.

Your committee submits as information a tentative draft of Specifications for the Formation of the Roadway, intended to replace those now appearing on pages 1–1–8 to 1–1–15, incl., of the Manual. Comments and criticisms concerning these specifications are invited.

SPECIFICATIONS FOR THE FORMATION OF THE ROADWAY*

A. GENERAL CONDITIONS

1. Work Included

The work covered by these specifications will be as designated by the plans, letter of invitation, and special provisions of the contract, and will consist generally of the necessary clearing and grubbing, excavation, placing of embankment, construction of ditches, channel changes, grading road crossings, including approaches, etc., as may be requested by the engineer.

2. Reliance Upon Estimates

The contractor shall take the work based upon his own information and judgment as to the nature and extent of the work, the availability of labor and conditions affecting employment. The submission of a bid by the contractor will be accepted as evidence that he has been over the work on the ground and is familiar with the conditions under which the work is to be done. Any information as to quantities or character of material to be encountered that may appear on the plans shall be accepted as an estimate only.

3. Precautions for Safety of Trains and Tracks

The work shall be so arranged that there will be no delay or interference in any manner with the operation of trains, and so as not to cause any interference with pipelines, signal wires, cables, telegraph, telephone or other utility lines. Blasting close to operated tracks shall not be done until proper precautions have been taken and arrangements made to protect all trains and other property and to quickly clear all debris from the track, in a manner satisfactory to the engineer.

4. Moving Company Tracks

Moving the company's tracks for the contractor's convenience will only be done at the contractor's expense by company forces or under company supervision and when authorized in writing.

---

* Refer also to Form of Construction Contract, Chapter 20.

5. Crossings of Operated Tracks

When a crossing is necessary to transport equipment or material across an operated track, the location and construction of the crossing shall be submitted to the company for approval, and it shall be constructed and maintained at the contractor's expense to the company's satisfaction.

6. Watchmen, Operators and Flagmen

Watchmen, operators and flagmen, both day and night, will be furnished by the company at places it may consider necessary for the safety of the company's trains and property, and the cost shall be charged to the contractor. The providing of watchmen, operators and flagmen shall not relieve the contractor from liability.

7. Safety Signals

All signals necessary to insure the safety of trains will be placed, maintained and operated by the proper department of the company. All instructions regarding their observance shall be obeyed.

8. Temporary Fences

Prior to or during the work of grading, suitable temporary fences or barricades shall be erected and maintained at contractor's expense, if necessary, in order to protect all persons from injury, and to prevent trespass upon the railway or damage to adjoining property.

9. Permits and Licenses

All permits and licenses and authorization of a temporary nature necessary for the prosecution of the work shall be secured and paid for by the contractor.

10. Roads and Crossings

Suitable roads and crossings for public and private use shall be provided and maintained by the contractor where necessary, as directed by the engineer, within the limits of the work. He shall provide and maintain safety or construction signs as required for proper notification of the public that work operations are in progress. All necessary appurtenances shall be provided at contractor's expense.

11. Cleaning Up

Before the work is finally accepted, the contractor shall, at his own expense, clear away from the company's property, as well as from public and private roads and channels of streams and ditches, all rubbish and surplus material and all contractor's tools, equipment and other property. The site shall be left in a safe condition to the satisfaction of the engineer.

B. CLEARING AND GRUBBING

1. Clearing

The right-of-way, station grounds and land provided for borrow pits, except any portion thereof that may be reserved, shall be cleared of all trees, brush, perishable materials of whatsoever nature and topsoil.

Where the area cleared is not to be grubbed, the height of stumps above ground shall not exceed the smallest diameter of the stump at its top and in no case shall the height exceed 18 in.

Buildings and structures to be removed are shown on the plans. They shall be completely removed at the lump sum price submitted in the contractor's bid.

2. Grubbing

Grubbing shall be done in all excavations and embankment areas and shall include the complete removal from the right-of-way of all stumps, roots and other embedded debris.

Portions of the right-of-way outside of excavation and embankment areas may be designated by the engineer to be grubbed.

3. Disposal

Unless reserved, all perishable material shall be burned or removed from the company's land without injury to adjoining property. Permits shall be obtained from local authorities and all regulations adhered to before any burning is undertaken. Contractor shall be responsible for any damage which may arise due to smoke or fires.

Strippings composed of a mixture of vegetation and earth shall be deposited in specified waste areas along berms outside of fill slopes or in other locations designated by the engineer.

All merchantable timber is the property of the company, and, when directed by the engineer, it shall be cut into specified lengths and piled, for which service force account will be paid.

4. Methods of Clearing and Grubbing

Clearing and grubbing may be done by any method that is not detrimental to the work or that is not wasteful of earth materials needed to make embankments. Skimming or stripping of the surface by means of scraper, bulldozer or blading machine will be permitted, but the contractor shall not waste earth incidental to such methods.

5. Progress of Clearing and Grubbing

All clearing and grubbing work shall be kept far enough in advance of other operations that it will cause no interference with or delay to such operations. Contractor shall notify the engineer sufficiently in advance of opening any borrow pit for him to approve and take field measurements.

6. Measurement and Payment

Clearing and grubbing will be measured and paid for by units of one acre or fraction thereof, actually cleared or grubbed.

C. GRADING

1. Definition

The term "grading" in these specifications includes all excavations and embankments required for the formation of the roadway, dikes, levees, ditching, road crossings, diversions of roads and streams, track-car set-offs, signal offsets, headblock dressings, earth bumping posts, and all similar work pertaining to the construction of the railway, its side tracks and station grounds.

2. Alignment

Embankments and excavations shall be built to the alignment shown on the plans and as indicated by the engineer's center, slope and finish stakes.

3. Dimension and Shape of Roadbed

The grade line on the profile, unless otherwise noted, will denote main track roadbed elevations on center line and indicates the surface ready to receive the sub-ballast or ballast.

The roadbed shall conform in dimension and shape to that shown on the appropriate ballast section in Part 2, this Chapter, and as indicated on the plans.

Roadbed and roadway shall be finished to the standard ballast sections, unless otherwise shown on the plans or directed by the engineer.

4. Ditches in Cuttings

Ditches in cuttings shall be made according to the plans, shall be neatly made, clear of obstruction, and at the lower ends shall diverge sufficiently to prevent erosion of the adjoining embankments.

5. Slopes

The slopes of embankments and excavations shall be based on the stability and erosion characteristics of the material concerned, but in no case shall be steeper than the following inclinations, as expressed in the ratio of the horizontal distance to the vertical rise:

Embankments	1½ to 1
Excavations: Common	1½ to 1
Solid rock	¼ to 1
Borrow pits	1½ to 1

Should materials of unexpected nature be encountered, or unforeseen conditions arise at any time after the excavation or embankment has been started, the engineer may require steepening or flattening or benching slopes, or widening of roadway, without any right or claim by contractor other than for the quantity of material actually moved, unless otherwise covered by written agreement in advance of these alterations being done.

When rock is unexpectedly encountered below the surface in making an excavation, the excavation shall be newly cross sectioned to slopes appropriate for the material encountered, and a berm of not less than (........) ft in width shall be left between the edge of the rock excavation and the toe of slope of the overlying material.

6. Berms

Unless otherwise shown on plans or directed by the engineer, berms of unbroken, original ground not less than the following widths shall be left between edge of embankment and near edge of borrow pit or surface ditch:

Embankments—20 ft or less in height	(........) ft
Embankments—over 20 ft in height	(........) ft

Berms of at least 3 ft shall be left between the outside edge of borrow-pit spoil bank or ditch and right-of-way line.

Where existing telephone or other poles are within borrow pits, a berm of at least 5 ft radius shall be left around each pole.

Where excavation is wasted or placed in spoil banks adjacent to top of cuts, it shall not be deposited nearer the top of the excavation than (........) ft. No material shall be deposited along excavations within (........) ft of the mouth of the cut, unless directed by the engineer.

7. Classification

All material excavated will be classified as Solid Rock or Common Excavation by the engineer while the work is in progress. Additional classifications may be established before the award of the contract. Material will be classified according to its condition at the time of its excavation, regardless of prior conditions.

(The following may be used as an alternate of the above: All material excavated will be classified as Unclassified Excavation.)

8. Solid-Rock Excavation

Solid rock will include all rock in solid beds or in compact, stratified masses which, in the judgment of the engineer, should be removed by continuous drilling and blasting, and which cannot be excavated with .... power shovel or cannot be rooted with a .... dozer containing two-tooth rooters.

9. Common Excavation

Unless other classifications have been established before the award of the contract, Common Excavation will include all materials that cannot be classified as Solid Rock, as defined in Sec. C, Art. 8.

10. Classification of Borrow

All material taken from borrow pits will be classified as Common Excavation, unless specific written instructions are given by the engineer to the contrary.

11. Measurement of Classified Material

When Common Excavation, and other classifications, established before the award of the contract, are removed from the same excavation, the volume of each shall be the actual measured quantity of each classification removed, if it is reasonably possible to determine in such manner.

If, in the judgment of the engineer, it is impracticable, because of mixture of the materials, to measure with a reasonable degree of certainty the actual cubic content of each kind of material, he will, from time to time, make such measurements as will, in his judgment, best aid him in arriving at a just and equitable conclusion as to the proper percentage of the materials of the different classifications in the entire excavation, and he will so separate and classify the different materials.

12. Excavation Below Subgrade

Rock excavation shall be taken out to a depth of .... (.........) in below subgrade and be backfilled to subgrade with approved select material. Unstable material in the bottom of a cut shall be removed to the depth directed by the engineer, and such excavation shall be backfilled with approved select material. The measurement of excavation will be made to the bottom of the material removed; but no payment will be made for backfilling, over and above the contract price for excavation of the material used for that purpose.

13. Frozen Excavations

The presence or action of frost shall not in any way influence or modify the various classifications herein described; when material is actually frozen, the engineer will classify such material according to his judgment of its proper classification when free from frost.

14. Borrow

Where the quantity of material from the cuttings of standard cross section is not sufficient to form the embankments as specified, the deficiency shall be made up by widening the cuttings on one or both sides to the extent and with the slopes directed by the engineer. Borrow pits shall be drained, if practicable, during construction and no depressions left that will hold water. If this is not practicable, the removal of the earth material shall be planned to reduce the effects of precipitation and such plan submitted to the engineer for approval.

Borrow pits shall not be excavated before they have been cross sectioned and they shall be of regular form, in order to permit accurate measurement.

The available borrow on the company's land is indicated in location and quantity on the plans. If additional borrow is required, or if alternative borrow is desired by the contractor, it shall be obtained by him at his own expense from a source approved by the engineer. Before excavating material from such outside borrow pit, the contractor shall secure from the owner thereof and deliver to the engineer a written release to the company from all damages arising from such use.

Borrow pits shall be left in a neat and regular shape, and they shall be made so that they will drain to the nearest water course, unless otherwise directed by the engineer.

Where topsoil is required to be stripped and stockpiled for the purpose of seeding or sodding later or as required by the engineer, no payment will be made for the rehandling of this material, unless specific written agreements are given by the engineer to the contrary.

15. Disposition of Materials

The materials from excavations incident to the construction of the subgrade, ditches, channels and roadways shall, so far as they are suitable, be used in forming the embankments. Frozen or other unsuitable material shall not be permitted to enter into the composition of embankments. Where earth and rock are deposited in the same fill, they shall be placed as directed by the engineer.

Where the quantity excavated exceeds that required to make the embankments to standard cross section, the surplus shall be used to widen the embankments uniformly along one or both sides, unless other disposition is shown on the plans or directed in writing by the engineer. Where wasting is so authorized, it shall not be started until the location, height and form of waste bank has been approved.

If the contractor should desire to waste off the right-of-way, he may do so only upon written approval of the engineer. Before entering on the ground he shall obtain easement from the landowner and release from the tenant in a form acceptable to the engineer. Such easement and release shall be at the contractor's expense.

The disposal of waste material and the borrowing of material in place thereof shall be entirely at the expense of the contractor, unless it is otherwise agreed in writing by the engineer.

16. Haul

Transporting excavated material will be considered as merely an incidental feature of all the grading work on the project. No so-called overhaul will be considered.

Vehicles used for hauling shall be satisfactory to the engineer and shall be sufficient in number and capacity for the work involved. The contractor shall route his hauling equipment over the grade in such a manner as to make maximum use of the compactive effort afforded thereby.

17. Blasting and Slides

When explosives are used in rock excavation, the charges shall be so proportioned and placed that they shall not loosen the rock outside of the excavation lines called for on the plans or as provided for in the specifications. If the rock below the line of the side slopes should be so loosened by blasting as to render it liable to slide or fall, such loosened rock shall be removed by the contractor without extra compensation, except as provided for in Sec. C, Art. 12.

Where blasting is liable to endanger persons or property, the engineer will have the power to prescribe and enforce such rules and regulations as may be necessary; but the prescribing or failure to prescribe such rules and regulations shall not relieve the contractor from any responsibility under the contract.

Slides, which in the judgment of the engineer are unavoidable, will be measured and paid for as excavation, according to the classification in which the material is found after the slide occurs.

18. Surface Ditches

Intercepting ditches, when shown on plans or ordered by the engineer, shall be made behind the top of the slopes of all cuttings and outside fills where the ground falls toward the center line. These ditches shall diverge sufficiently to prevent erosion of the embankment. The cross sections and locations of such ditches shall be as designated. If required by the engineer, they shall be excavated in advance of opening the cutting or making the fill.

19. Subdrains

Pipe subdrains shall be constructed of the material, size and design, and in the location shown on the plans, and to the depth and grade established for them. The cross section of the trenches shall conform with the plans, and the trenches shall be excavated and the pipe laid to true line and grade. Corrugated metal subdrains shall be installed with the perforations down. Sufficient cribbing or shoring shall be used to prevent caving of the trench excavations. The excavated material shall be disposed of as directed by the engineer.

All trenches shall be backfilled with concrete sand, within the ASTM limits for concrete sand, and compacted as approved by the engineer. The finished section of the backfill shall conform with the plans.

Measurement and payment for such drains will be made by the linear foot, according to the diameter of the pipe and its located depth, including excavation, backfilling and disposal of excess material.

20. Roadway Embankments

Roadway embankments shall be placed and compacted in layers as hereinafter specified.

Where there is a choice of material, the most suitable shall be used in the top of the embankment for at least 2 ft in depth. No stones or lumps larger than (........) in. in diameter shall be permitted in the top foot of depth. When embankments are formed of large quantities of stone, slag or gravel, the material shall be carefully placed so that the large granular material shall be well distributed and the interstices shall be completely filled with smaller material or earth to form a dense, solid embankment.

21. Formation of Earth Fills

Unless otherwise directed by the engineer, embankments of earth shall be built in horizontal layers of not more than 6 in. in thickness after compaction. Large pieces or lumps of material shall be broken by discing or appropriate equipment. The layers shall be the full width of the embankment, without depressions between slopes, built to true slope and not widened with loose material from the top. Layers shall be compacted as evenly and as densely as possible by distributing the hauling over the entire area of fill already placed. Snow and ice shall be removed before placing grading material. Rubbish, ice and snow will not be permitted below or in embankments, and no payment will be made for their removal.

Compaction of each layer of the embankment shall have an average of not less than 90 percent (or as specified by the engineer) of the maximum density as determined by ASTM Specifications (D 698–58T—Moisture Density Relations of Soils Using 5.5-Lb Rammer and 12-In Drop) for each soil at its optimum moisture content. These tests shall be made at the direction of the engineer and will be paid for by the company.

Whenever the embankment has not received sufficient compaction, the placing of material shall cease until proper compaction is obtained. If the fill material is too wet for proper compaction in the opinion of the engineer, filling shall be stopped and the material removed or allowed to dry to the proper water content before fill operations are resumed.

The contractor shall, at his own expense, add water uniformly by means of an approved distributor to all fill material which, in the opinion of the engineer, is deficient in water content.

22. Formation of Rock Fills

Embankment built of material containing rock larger than 6 in. in greatest dimension shall be constructed by placing the material in layers not exceeding the maximum size of the rock present, but in no case shall the thickness of layers exceed 18 in. Layers shall extend the full width of the roadbed, and a dense, solid embankment shall be obtained for the full width by distributing the stones over the area and filling between them with sufficient fine material to fill the interstices. Each layer shall be compacted by sprinkling and routing the spreading equipment and the loaded hauling equipment over the entire width of the fill until compaction is obtained. If necessary to get adequate compaction, in the judgment of the engineer, a smooth power roller, or other means, shall be used.

23. Compaction Equipment

Choice of compaction equipment shall be made by the contractor with the approval of the engineer. In giving or withholding his approval of any compaction equipment, or its use, the engineer will be the sole judge of factors to be considered and their relative importance. If a sheepsfoot roller is used, it shall be properly weighted, have dual drums and be a minimum of 60 in. in diameter. If a rubber-tired roller is used, it shall be fully weighted and have a minimum weight of 30,000 lb. The amount and type of compacting equipment shall be sufficient to properly compact the fill at the rate at which material is being placed.

Where compacted fill is to be placed in the vicinity of trenches, culverts or test pits and against abutments or piers where it is impractical to use normal compaction equipment, the fill shall be placed in horizontal layers with a maximum uncompacted thickness of 6 in and compacted with hand-operated equipment, approved by the engineer, to the same density as specified for compacted embankments. Power tampers used for hand compaction shall have a minimum weight of 100 lb.

24. Embankments on Swampy Ground

Where embankments are to be constructed across low or swampy ground which will not support the weight of trucks or other hauling equipment, the lower part of the embankment may be constructed by dumping successive truck loads of select material in a uniformly distributed layer of a thickness not greater than that necessary to support the equipment while placing subsequent layers. The remainder of such embankment shall then be constructed in layers and compacted as specified in Sec. C, Art. 21. If directed by the engineer, boggy ground or unsuitable material shall be excavated so that the embankment will be on a firm foundation. In such cases, the material will be paid for at the same unit prices that apply to the grading of the roadway.

25. Embankments on Slopes

Where embankments are placed on side-hills or adjacent to an existing embankment, the vegetation shall be removed and the surface shall be plowed or stepped with furrows 12 in deep measured normal to the adjacent ground surface, before placing any filling material. Such plowed material shall be spread on adjacent new fill and compacted and rolled. No payment will be made for this work.

26. Embankments at Trestles and Over Masonry

The material shall be spread uniformly, without depressions between slopes, and shall be thoroughly compacted around and under all parts of the structure by means of the appropriate compaction equipment as called for in Sec. C, Art. 23. No part of a trestle shall be left in the embankment within (........) ft of the ultimate subgrade. Large stones shall not be placed within (........) ft of the extrados of any arch, and filling shall be deposited simultaneously on both sides of it. Waterproofing on masonry shall be kept undamaged. The unit price for excavation will include this work.

27. Compacting Excavation Base

When necessary, in the judgment of the engineer, the bases of the excavations for a width of not less than 7 ft on each side of the center line of the track, or between lines 7 ft outside the center lines of the outside tracks, shall be plowed, scarified, excavated if necessary, and broken up, and shall then be moistened and compacted to a depth of 6 in below the finished surface of the excavation section and shall have an average of not less than 90 percent (or as specified by the engineer) of the maximum density as determined by ASTM Specifications (D 698–58T—Moisture Density Relations of Soils Using 5.5-Lb Rammer and 12-In Drop) for each soil at its optimum moisture content. In cases where the engineer may require excavation of unsuitable material below subgrade and backfilling to subgrade level with suitable material, the work will be paid for at the unit price for the material excavated.

28. Finishing Roadway

The roadway shall be compact and finished to a true surface and no depression left that will hold water or prevent proper drainage. The roadbed shall be finished to within 0.1 ft of elevation on stakes, shall have a crown of ¼ in per ft and be uniform and free from sharp breaks in surface. Where sub-ballast is required by the plans, it shall be placed by trucks or other earthmoving equipment and precautions taken not to rut the finished roadbed. Before placement of sub-ballast, no trucks or heavy equipment shall be allowed on wet finished subgrade.

29. Finishing Excavated Slopes

All excavated slopes shall be trimmed accurately to approved cross sections. In rock or other material, when in the judgment of the engineer a true slope cannot be made, a modified slope will be permitted. No loose material shall be left on the sides or in the bottom of any excavation.

30. Slope Erosion Control

Topsoil reserved as provided in Sec. C, Art. 31, shall be deposited on slopes as called for on the plans or as directed by the engineer.

31. Reserving Excavated Material

Gravel, stone, topsoil or any other material suitable for special use of the company, which is found within the excavations, shall, when required, be reserved or stockpiled and deposited in convenient places on the right-of-way, as directed. Other suitable material in the vicinity will be substituted, as required, to complete the embankments.

32. Measurement of Grading

Grading will be measured by the cubic yard of excavation of proper classification in the original space occupied for all accepted excavation.

Excavation in excess of the authorized cross section will not be included in the measurement except in removal of unpreventable slides.

Material obtained from sources that do not permit accurate measurement may be measured in embankment or in cars, with such proper allowances for change in bulk as shall be agreed upon in advance.

33. Payment for Grading

Payment for grading will be by the cubic yard of excavation of proper classification and will include the furnishing of all labor, materials, tools, equipment and supplies and supervision necessary for excavating materials by whatever method is adopted; loading, transporting and depositing same in embankments, or where directed; and all rolling or compaction of embankments, supplying and applying water for compaction, embankment foundations and excavation bases; scarifying, plowing or benching of slopes; also all placing and tamping around existing structures, outside of structure backfill, distributing or finishing.

Payment for placement for reserved topsoil will be by the acre of topsoil applied (........) in loose thickness.

34. Sub-ballast

Where sub-ballast is called for, it shall be provided as called for in Part 2, this Chapter.

35. Drainage Structures

Culverts shall be installed as called for in Part 4, this Chapter.

D. FINAL INSPECTION AND ACCEPTANCE

All inspection by the engineer is for the protection of the company and its interest and shall not relieve the contractor of his responsibility for giving good work of the kind required by the specifications and plans. After completion of the work, a final inspection will be made, and any previous inspection or acceptance will not preclude rejection at the final inspection of anything that is not satisfactory or not in accordance with the specifications. The date of formal acceptance will be established by the engineer, and all reshaping, dressing or other work required after this established date will be paid for as extra work.

Report on Assignment 6 (a)

Roadbed Stabilization

Part 1—Soil Stabilization by Chemicals

Recently a chemical with the trade name "SA–1" has been advocated by its manufacturer as a stabilizing agent capable of reacting in fouled ballast in such a way as to make the ballast more drainable. It is claimed to have a similar action on soils, reducing the effects of water pockets in the subgrade and instability from soft track. Two railroads have used this material on an exploratory and experimental basis, and the applications have been observed by a member of the AAR research staff.

The following report on this chemical is sponsored by Committee 1 and was prepared under the general direction of G. M. Magee, director of engineering research, and Rockwell Smith, research engineer roadway, AAR.

As reported by the manufacturer, the principal function of SA–1 is to remove from the soil organic combinations and certain chemical radicals that contribute to instability in soils when wet. This apparently applies to ballast also. In addition, it is claimed that the chemical tends to increase the internal friction and produce better internal drainage, and to produce additional densification of the materials and reduce the frost effects. The chemical has apparently been used on highways, particularly the unsurfaced gravel type, and there are indications that some benefit has been derived in the more rapid drying of these roads, presumably because of improved drainage. However, this has yet to be fully demonstrated, according to several reports from highway departments. It is not recommended for soils containing 50 percent or more clay unless the soil is modified with the addition of granular material. It is, however, reported beneficial to bare cut and fill slopes, providing action which reduces erosion and prepares the soils for a more favorable seed bed.

WESTERN PACIFIC APPLICATIONS

The Western Pacific applied SA–1 to three one-half mile sections of track in California and Nevada. The first of these was an application over the top of an embankment area near Sacramento, Calif. This area has a heavy clay subgrade with high swelling and shrinkage properties, and the track has been expensive to maintain. Water pockets developed, causing irregular line and surface. The chemical was sprayed on the ballast section and both shoulders to a width of 21 ft. (See Fig. 1.)

The manufacturer's recommendations were followed rigidly. The application consisted of 12 gal of SA–1 in 8,000 gal of water followed immediately with the application of 10,029 gal of clear water. Neither the chemical nor the water was applied in a single application. Five trips were required for application of the chemical and four trips for the water to prevent complete saturation and run off, particularly on the shoulder sections. Modified weed spray equipment was used. This test application was made to determine the effect of the chemical in changing the character of the embankment's soil to a more pervious one, allowing lateral drainage.

The second test section, approximately one-half mile in length, is in the Smoke Creek Desert of Nevada where the ballast is fouled by silts and alkali dust during wind storms. The combination of the alkali and silt causes a crust which at times has shorted out the signal circuits. Sand fences are fairly effective in controling this situation, but

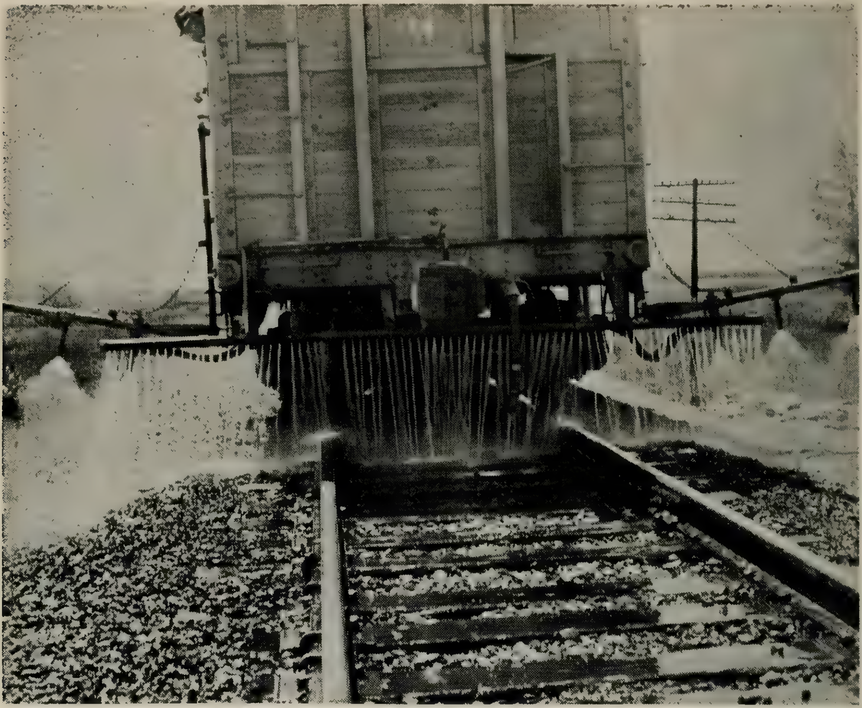


Fig. 1—Applying SA–1.

the SA–1 was applied in an area not so protected. The object of the test was to evaluate the ability of the chemical to open the ballast to a drainable condition.

As in the first section 10 gal of chemical added to 8,000 gal of water were applied, followed by 22,000 gal of water, both in multiple passes to a width of 14 ft.

Test area No. 3 is also in a desert area between Reynard and Phil, Nev., and is also approximately one-half mile in length. Prior to the application of the SA–1 the track at the tie ends and in the rail cribs was cleaned, but during the test applications a windstorm blew in alkali silt, filling the cribs soon after completion. In this area there has been a serious interference in signal operation in high-speed territory.

The same general procedure was followed as for the other two test sections, using 10 gal of SA–1 to 8,000 gal of water and 22,000 gal of clear water applied in multiple passages of the spray train. Over the ballast section, however, where the water was readily absorbed, the bottom valve of several tank cars was opened to speed the operation. The amount of opening was controlled to insure maximum water application without flooding. A 9-ft 7-in spray bar was used for application of the chemical, producing a width of treatment of approximately 10 ft.

SANTA FE APPLICATIONS

The Santa Fe applied the SA–1 chemical over four sections in Texas in a test program similar to that on the Western Pacific. Section No. 1 includes the entire area (5,280 sq ft) of a high fill. The chemical was applied to a width of 120 ft. The track is unstable in this section, which has indications of incipient slides. Comparable sections of fill adjoining the treated area on both ends will serve as control sections to determine the effects of the application. The manufacturer's recommendations were followed, using 1 gal of chemical to 1,000 gal of water with an equal application of water following the chemical. Hand hoses were used for the slopes and shoulder outside the reach of the self-propelled spray equipment.

On section No. 2 the area was split into two parts totaling 5,280 sq ft. The width of application was 25 ft over the top of the grade. The section between the two treated parts will serve as a control area. The track area throughout is soft with high maintenance requirements.

The third section treated is on a low fill south of Gainesville, Tex., over which the ballast was appreciably fouled. Spray width was 16 ft over a total of 5,280 sq ft using the same dilution and water treatment as in the other sections. Similar conditions of ballast occur immediately to the north of the treatment, providing a good check area for comparison.

The subgrade soils throughout all the first three sections are heavy plastic and swelling clay.

The fourth section, which was not observed during treatment by the AAR staff, is near Clay, Tex. From information supplied by the Santa Fe, the conditions in the area, which also has a heavy clay subgrade, has resulted in the ballast settling into the subgrade, and the track requires continual maintenance to retain line and surface. The procedure for application of the chemical was similar to that of the other three sections. The spray width was 25 ft. Similar track conditions appear at the end of the treated area, so direct comparison can be made as to the efficiency of the application and chemical.

CONCLUSIONS

It was not expected that definite results on any of the projects noted above would be apparent at the time this report was prepared. These sections, however, will be continually observed for the next several years and further reports made as data are available. If the SA–1 chemical can even approximate the manufacturer's contentions, a valuable aid for stabilization will be available. At present, in small quantities, the cost per mile for the chemical to cover a 12-ft ballast section is approximately $300.

Part 2—Effect of Irrigation System on Railroad Embankment on Northern Pacific Railway in Vicinity of Mesa, Wash.

The following report discusses a condition on the Northern Pacific Railway in which the subgrade in the vicinity of Mesa, Wash., was adversely affected by the rise in the water table from the use of irrigation waters. The report includes a discussion of aerial photography—both normal aerial surveys and infrared coverage. The report is self explanatory in these respects, but it should be noted that the use of infrared photography is a new or previously little-used method for the tracing of ground water. The railroad is to be commended for its employment.

In addition to the above investigations, engineering officers of the Northern Pacific and a representative of the AAR research staff inspected the area in the Fall of 1963. Notes from this inspection show that the water table at that time was approximately 1 ft below natural ground and in places within 2 ft of the bottoms of the cross ties. Under these conditions rather soft track resulted and a speed restriction was in effect. (See Fig. 1.)

The soils are generally silts characterized by high water-holding capacity and high capillary potential. Continued and periodic ballast applications have resulted in depths of granular material of 4 to 7 ft below the ties, the subgrade soils having been displaced outward. The track is on the original location built in 1880. Loss of stability appeared first in 1953 and 1954 and had become progressively worse. Other features of the area are covered by the report of J. W. Keim and A. B. Berg which follows:

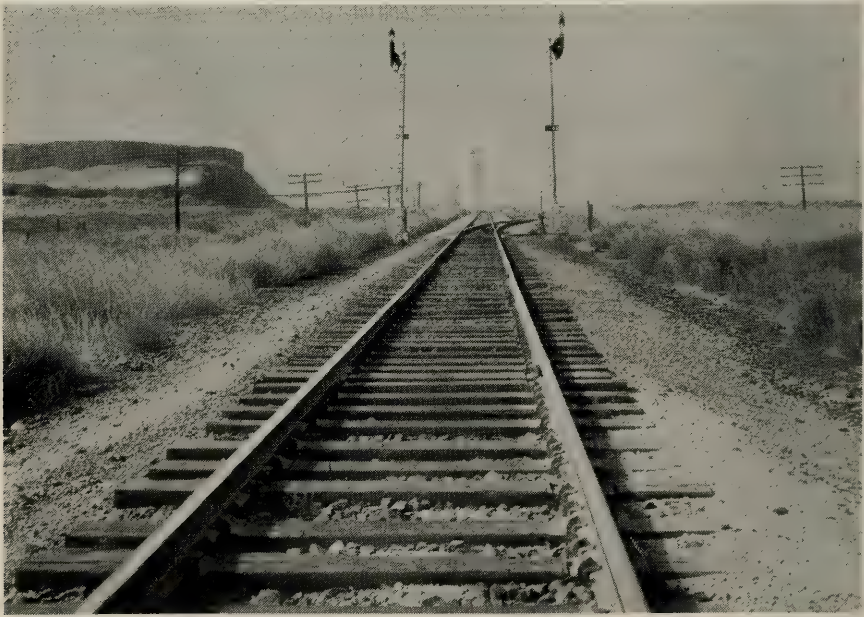


Fig. 1—The high moisture content of the subgrade due to irrigation caused this stretch of track to become unstable.

Report of Investigations of Disturbed Track Condition at Mesa, Wash.

By J. W. Keim* and A. B. Berg*

INTRODUCTION

On May 2, 1962, the second phase of a geologic study in the area adjacent to the disturbed track at Mesa, Wash., was begun. The purpose of this work was to substantiate and supplement the information previously obtained through photogeologic interpretation by additional field examinations, studies of 1955 aerial photography by the Commodity Stabilization Service, USDA, and by study and interpretation of infrared aerial photography. As a result of this work and also of conversations held with Bureau of Reclamation and United States Corps of Engineers personnel, much additional information has been gathered. This information helped in arriving at an understanding of geologic events which took place to cause the conditions which now exist at Mesa and also sustains the contention that the irrigation program of the Bureau of Reclamation directly caused the saturated water condition in Esquatzel Coulee. A review of these geologic events is important in determining what steps should be taken to alleviate this condition. (For orientation and reference in locating the various points referred to in the following text, see Plate I).

The major drainage in the Mesa area, now known as Esquatzel Coulee, was developed as part of the Palouse drainage system in southeastern Washington on Miocene lava flows. From later Miocene time (10 to 15 million years ago) to sometime during the glacial period, the floor of the coulee accumulated a thick bed of coarse sand and gravel. During the glacial interval a series of events took place which caused several vast floods to transgress southeastern Washington, each lasting but a few days. Because of the great magnitude of water, these floods were not entirely controlled by topographic land forms. However, at the end stage, as the water subsided it followed the ancient drainage patterns.

As these subsiding waters, still very forceful, moved through Esquatzel Coulee and the narrows at Mesa, they plucked and scoured the walls and floor of the coulee and created a "pothole" in the gravel bed. The load of the flood water in its later stages consisted mainly of silt, and when the water was restricted by the narrows at Mesa, it ponded, dropping its silt load. The silts eventually filled the coulee floor to grade level, and the present configuration of the Esquatzel drainage was established. Because of their very low coefficient of permeability, the silts partially dammed subsurface waters moving through the coulee toward the Columbia River.

After the glacial flooding only periodic discharge of relatively little water flowed through the Esquatzel Coulee. This is indicated by the relic meander scars and thin-bedded flood plain deposits on the present coulee floor. The water table apparently remained at a substantial depth beneath the surface, and according to the Bureau of Reclamation, prior to 1954 the water table northeast of Mesa was 26 ft lower than it is today. As the irrigation blocks west and north of Mesa were charged, additional subsurface water began to move into Esquatzel Coulee. The silts became saturated, and because they inhibited subsurface water movement they, in effect, created a subsurface cascade. The difference in the elevation of the water table above and below Mesa is now about 30 ft.

---

* Photogeologist and district mining geologist, respectively, Mineral Development Division, Properties and Industrial Development Department, Northern Pacific Railway.

Plate I.

RESULTS OF FIELD INVESTIGATION

Before the field investigation was started it was learned from discussions with representatives of the Bureau of Reclamation, that they had anticipated trouble in the Esquatzel Coulee north of Mesa and consequently conducted a study to determine if they could be held liable for damages as a result of their irrigation program. The investigation showed that the water was commingled, that is, made up of water derived from irrigation and from wasting. Consequently the Bureau decided that it was not liable and abandoned its work in the Esquatzel Coulee.

As a result of the meeting, enough information was obtained to show that the saturated water condition is a direct result of the irrigation project and is not due to normal runoff. The Bureau's records show that the water table began to rise in 1953 as irrigation block 12 (the block west and northwesterly from Mesa) was charged; from 1953 to 1958 the water table rose from 655 ft at Bailie's well to 664 ft. From 1958 to 1960 the water table rose to 678 ft; from 1960 to 1962 the water rose to 681 ft. During the summer months of 1953 to 1958 when the ratio of water used in irrigation to water wasted was high, the water table was drawn down. In 1958, however, when block 18 (the block due north of Mesa) was charged, the drawdown during the summer months decreased considerably; in late 1959 the water table leveled off, and thereafter it has maintained a somewhat linear yearly increase in elevation.

The flooding of the coulee, according to the Bureau, was anticipated by extending the trend of the water table rise using the lowest points in the table from the years 1954 to 1958. The graph which represented this curve showed that the coulee would be flooded by 1963. However, this happened late in 1959. The reason for this, according to the Bureau, was that a miscalculation of the amount of water to be used by the farmers resulted in wasting a larger volume from block 18 than had been anticipated. This unpredictable situation caused the coulee to flood three years earlier than indicated by the project curve.

The tests made by the Bureau showed that a ground-water falls or cascade did exist at Mesa, and this profile was changed considerably by the construction of an investigation ditch installed by the Bureau on Mrs. Poe's property along the northwest toe of the coulee wall north of Mesa. The falls retreated upstream to approximately the grade crossing at Highway 11G. (Plate I)

Field examination substantiated the information derived earlier from the photogeologic study. However, at the time of our examination, the water in Waste Lake "A" was down approximately 20 ft below the level of water at the time the air-photos were taken. Also, actual evidence of water escaping from Waste Lake "A" or from irrigated lands was very difficult to detect. Only two water seeps or springs were found along the north wall of the Esquatzel Coulee, one from a strong structural zone above the ditch at Mrs. Poe's place and the other along the toe of the north wall approximately 800 ft east of Highway 11G. It appears likely that in the former case (the strong influx into the ditch near Poe's), a good proportion of this water must originate in Waste Lake "B". No water was detectable around Cactus quarry or the roads between it and Waste Lake "A". There was standing water, however, on the road by the waste lake.

Dry Coulee showed water at the mouth and up the draw as far as the water table would enter the mouth and also near the irrigated land 4¼ miles north of Esquatzel Coulee; otherwise, the coulee was dry. One reason for the difficulty in detecting leakage water was that at the time the field check was made (early spring) the area was not fully charged.

RESULTS OF STUDY OF COMMODITY STABILIZATION SERVICE PHOTOGRAPHY AND INFRARED PHOTOGRAPHY

Panchromatic aerial photography of the Mesa area was obtained by H. O. Tutmark, Northern Pacific photographer-pilot, on October 17, 1961; the results of the examination of that photography were reported in a letter dated March 15, 1962, to E. E. Thurlow, chief mining geologist. We have since obtained the 1955, 1:20,000 CSS photography in order to compare surface water conditions before and after the irrigation was started in block 18. Infrared photography was flown by Mr. Tutmark in September 1962 for use as a possible aid in determining subsurface water courses leading into and following along the coulee and to outline the pattern of damp and saturated zones.

1955 CSS Photography

The contrast in surface moisture indicated by comparison of the 1955 CSS and 1961 Northern Pacific aerial photographs is extreme. For all practical purposes there was no surface moisture in evidence in 1955 (photography obtained in July of that year); yet, in 1961 there are several areas where water is present. A list of the differences follows:

1. In 1955, a little water was beginning to collect in Waste Lake "B" depression and in the deepest part of the Mesa gravel pit. This was probably at the level of the water table which was about 25 ft below the coulee surface. In 1961, the Mesa pit was flooded to within a few feet of the coulee surface.
2. The depression now occupied by Waste Lake "A" (local name, Tee Lake) and the depressions in the basalt flows immediately around it were completely dry in 1955 and did not even show evidence of salting which would result from occasional moisture and attendant evaporation. In 1961, these depressions were charged with water.
3. In 1961, several localized areas along the toe of the north coulee wall showed relatively dense vegetal growth—evidence of ground moisture; in 1955, these small areas showed little contrast with the surrounding area. Also, a number of fractures intersecting the coulee wall definitely showed more vegetal growth in 1961 than in 1955.
4. In 1955, the area just south of the right-of-way and east of Highway 11G showed no evidence of moisture. In 1961, this area was quite marshy, with a little water standing at the surface.
5. In 1955, there was no water in the main channel of the coulee; in 1961, water appeared in the channel gravels at Bailie's house (½ mile east of Highway 11G).

In short, the effect of irrigation in block 18 is clearly expressed in the contrast of surface water conditions as recorded by the 1955 and 1961 photography.

1962 Infrared Photography

In October 1961 it was suggested that infrared photography might be useful in tracing the movement of ground water in the Mesa area. Wet or damp areas radiate and reflect less heat energy (infrared wave length) than dry areas, and film that is sensitive to this spectrum of radiant energy records these differences in the same manner as panchromatic film records the different intensities of visible light.

The first attempt at obtaining infrared photography in 1961 was not satisfactory. In the spring of 1962, test strips of the area were taken using an 89–B filter in the 12-in camera. It was decided on the basis of these test strips to photograph the area again and in September 1962 infrared photography was successfully obtained.

A very interesting pattern is subtly expressed on the photos in the area of the bad track condition. Just east of Highway 11G in the cultivated fields adjacent to Bailie's place a flow pattern is suggested (see Fig. 2). Definition of this pattern is lost in the fields east of Bailie's toward the Mesa gravel pit. There is only the faintest suggestion of tonal difference in the cultivated fields. However, there is definite evidence of water movement along the toe of the coulee wall directly north of the apparently dry area, and it also appears likely that water is entering the coulee from the small waste pond that has developed above the coulee to the northwest of Bailie's. These are the probable prime sources of the water moving across the cultivated fields toward the subsurface cascade and the right-of-way. There is also photographic evidence that subsurface water moves south-southwesterly across the grazing area between the Mesa pit and the main channel and right-of-way.

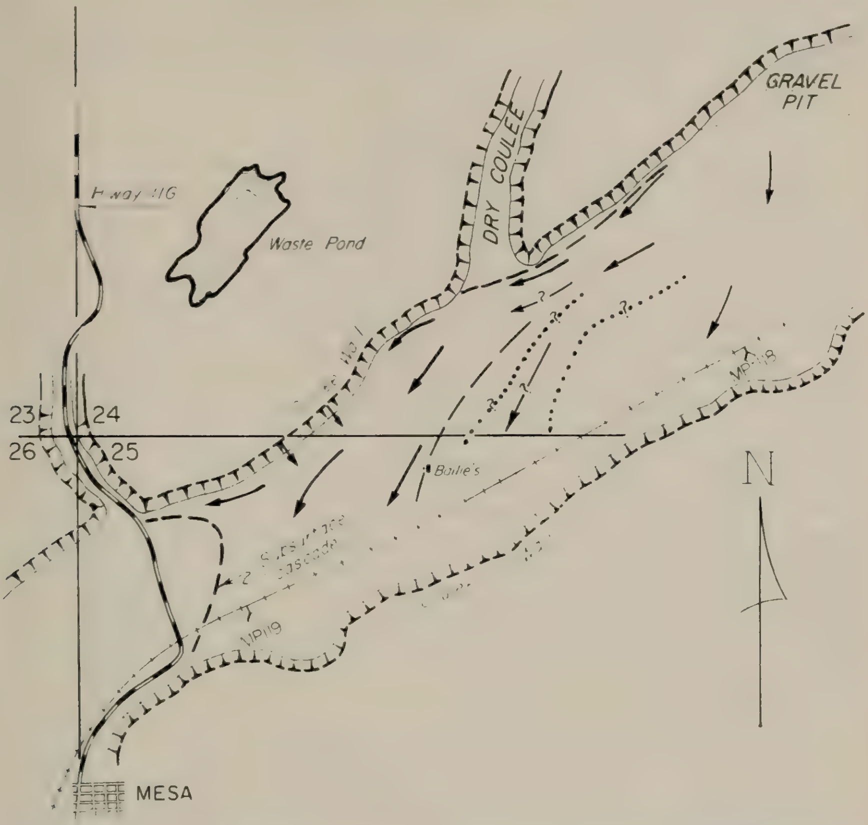


Fig. 2—Sketch map showing suggested dispersion pattern and flow direction of subsurface water in Esquatzel Coulee.

Despite its depth, Dry Coulee, which joins Esquatzel Coulee about ½ mile east of Highway 11G, shows no evidence of moisture along its bottom. There is one low spot about 2500 ft above the mouth of the coulee which exhibits possible evaporite development suggesting recent water movement. Evaporite material also appears in the marshy area south of the railway, just east of the Highway 11G grade crossing.

Between Waste Lake "A" and Esquatzel Coulee no definite pattern is defined. There is evidence of moisture along the coulee wall near Cactus Quarry, and mapping of the flows visible on the scarp face indicates that this condition is related to one particular flow, which in the area of Waste Lake "A" is either at or just below water level. Possibly a permeable zone is developed in or at the base of this flow serving as a channelway for water to flow from the waste lake to the coulee.

At Cactus Quarry there is no discernible dampness or evidence of water movement; in the bottom of the small reentrant just east of the working face there are indications of evaporite development. Easterly from Cactus Quarry and opposite M.P. 114 a well developed break or fracture cuts the north coulee wall, forming a channelway for a small stream of waste water entering the coulee. The distribution of the water is clearly marked on the floor of the reentrant; 1200–1300 ft north of the nearest point on the railway's right-of-way, the water apparently disappears into the coulee fill.

SUMMARY

From the records of the Bureau of Reclamation, geologic field work, and photogeologic interpretation, it can be clearly demonstrated that the irrigation program of the Bureau is directly responsible for the saturated water condition in the Esquatzel Coulee northeast of Mesa. This fact was strongly indicated before the present investigation was begun, but we believe the evidence now at hand is conclusive. The questions that remain are: how effective is this evidence in proving liabilities, and how can it be used to relieve the condition that exists in the coulee? The answers to the former are not encouraging. Although we can show the source of the water, it is nearly impossible to ascertain what percentage is waste. The use of dyes or other detection devices would only substantiate further what we already know. In order to determine to what extent the waste water is contributing to the ground water reservoir above the subsurface cascade, a complete hydrologic study would have to be performed, but because of the many variables involved, the results very likely would be inconclusive.

Furthermore, a study of the water-table curve shows a point in the Bureau's favor. From 1954 to 1958 the water table in the coulee rose at an average rate of 2¼ ft/year. This was due to irrigated lands in block 12. As block 18 was charged, the table rose 7 ft/year from 1958 to 1960. During this time Waste Lake "A" was filled. Now with three systems draining into the coulee, that is, block 12, block 18 and Waste Lake "A", a sharp increase in the rate of water table rise would be expected. However, from 1960 to 1962, the rate was only 1½ ft/year—less than that during the period when only block 12 was active.

There are probably several reasons for this, one of them being better regulation of the irrigation water resulting in less wasting. A second reason, and one that is of greater importance to the problem of the disturbed track, is the investigation ditch put in by the Bureau near the Poe farm. It is probably not possible to measure its effect quantitatively, but it does appear that this ditch has drawn off most of the water originating from Block 12 and Waste Lake "B". Since its completion the subsurface falls has retreated upstream about ½ mile, and removal of this water from a part of the silted area is apparently allowing more rapid movement of water through it from the upstream side.

It is clear that the waste waters of Lakes "A" and "B" and the small pond northwest of Bailie's are not the sole contributors to the water-table rise and the flooding of the right-of-way and the Poe and Bailie fields. What is not clear is their contribution to the actual condition of track instability, at least up to the time of this writing. The seasonal nature of this condition argues that the waste waters have a large share of the final responsibility; all of the waste lakes reach an equilibrium level where discharge (all subsurface) keeps pace with charge (mostly surface), and the period of this state of equilibrium, or stage of rapid discharge, generally coincides with the period of track instability.

One recent development which may prove to the railway's advantage is the signing of a new contract by the United States Bureau of Reclamation which superseded the original Coulee Dam irrigation project contract initiated in 1938. The new contract allows the Bureau additional monies for the development of new irrigation tracts and also includes an allowance for adequate waste drainage. Whether this can be applied to

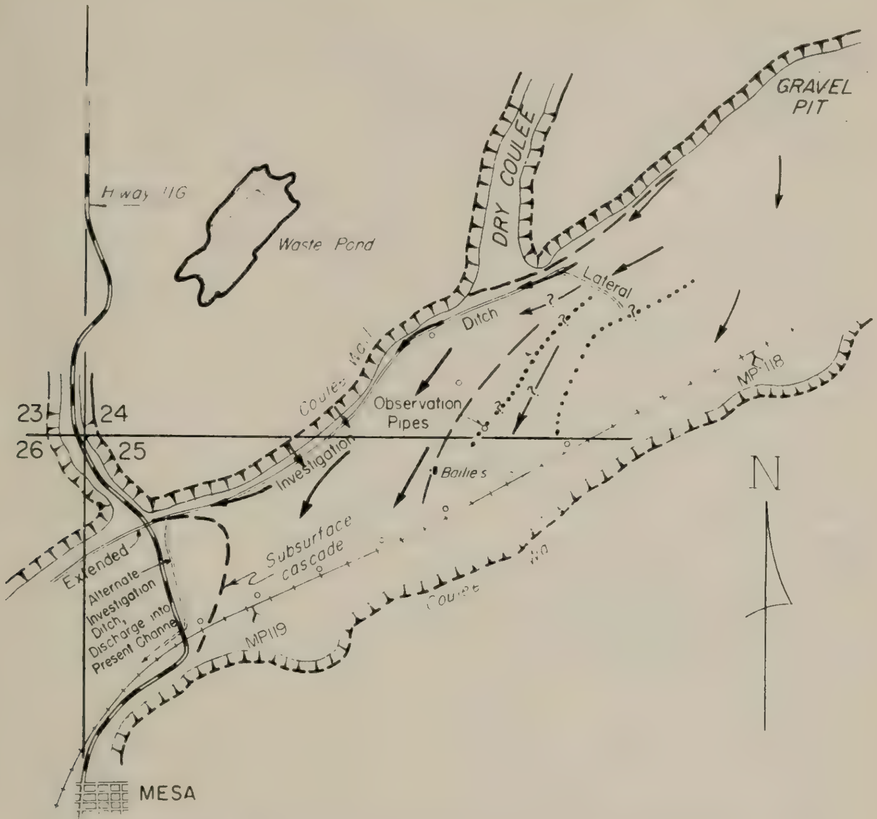


Fig. 3—Sketch map showing location of proposed observation pipes and extended investigation ditch.

completed districts is not known, but it may open the way for new negotiations with the Bureau.

In answer to the second question, the information that has been gathered may help to determine a solution to the saturated water problem that is causing the bad track condition. The infrared photos show the apparent pattern of water dispersion, and the investigation ditch shows what can be done by intercepting leakage water. By diverting the subsurface water upstream from the bad track area and channeling it along the toe of the north wall, a considerable drop in the water table should be realized. Laterals to the track area may be needed if the drop is not sufficient. This plan has been confirmed by the Corps of Engineers' geologist and soil men as the most logical approach.

Another method of relieving water from the area would be the use of trees and plants with high transpiration factors. The type of plant or tree which obtains its supply of water either directly from the zone of saturation or through the capillary fringe is termed a phreatophyte. In effect, they act as large pumps, transpiring hundreds of gallons of water daily. Willows, cottonwoods and alders are examples of this type.

Apparently the use of trees in this particular problem is quite unique. Many studies have been made on transpiration ratios of trees and plants but mainly for the purpose of limiting this action in the conservation of water. We have only recently conceived of this idea and it is still being explored. K. L. Cook, western agricultural development agent, has been consulted as to its feasibility, and he is presently making a study of the matter.

RECOMMENDATIONS

1. Pipes should be installed parallel and normal to the track for the purpose of developing the water-table gradient and for future observations and measurements. Two-and-one-half inch pipes fitted with screen filters, placed about 5 ft below the water-table surface and spaced 500 ft apart, as shown in Fig. 2, should accomplish this. Readings relative to collar elevation should be taken at two-week intervals. The installation of the pipes is important in determining what effect the work done will have on the water table.

2. The investigation ditch at Mrs. Poe's farm should be extended along the toe of the north wall far enough to intercept the leakage water. This should be almost to the gravel pit (see Fig. 3). An alternate to this would be to extend a ditch north to the coulee wall from the main channel just east of Highway 11G, then continue easterly along the toe. This would collect and carry water across the crest of the cascade to a point where the main channel can apparently handle it.

3. If observations indicate that the water table is not being adequately lowered, laterals to the track should be constructed.

4. In conjunction with the ditching and if thought to be feasible by Mr. Cook, trees with high transpiration rates could be planted along the right-of-way.

[The following paragraphs were added by the AAR Research Department.]

In May 1964, 1500 track feet were grouted over the most seriously disturbed area near Mesa, Wash. For this work grouting points 5 ft in length were used which in most cases reached the bottom of the ballast material built up during the years of high maintenance. These points were placed at 10-ft intervals on each side of the track but staggered so that there was an injection every 5 ft of track.

The original grouting mixture tried consisted of 4 parts of sand to one part of cement, but acceptance was low and neat cement and water was used for most of the job. Acceptance averaged approximately 1½ cu ft per track foot.

Immediate results were obtained from this operation, and the track has continued to be very serviceable to date. Speed restrictions were removed. Future plans call for grouting in 1965 of approximately 4400 additional track feet. It was reported that water conditions in the area were less severe this year than previously and that the track was less affected by the high water table. This is not considered to be the usual condition so the additional grouting was programmed.

The deleterious effect of irrigation waters on the stability of at least four sections of track has come to the attention of the AAR research staff. These conditions were not similar to those of the Mesa area in that the irrigation was on the slopes above the track, but it was the use of irrigation waters that caused the track instability. It is probable that additional unstable sections will develop with the continuation of dam construction for agricultural purposes.

Report on Assignment 7

Tunnels

(a) **Ventilation; Changes Necessary for Operation of Diesel Power**
(b) **Clearance; Methods Used to Increase, Collaborating with Committee 28**
(c) **Methods of Open Cutting**

K. W. Bradley (chairman, subcommittee), D. H. Cook, M. W. Cox, L. G. Reichert, H. E. Richards, A. P. Crosley.

Your committee reports on Assignment (c) only, as information.

Excavation of a Through Cut to Replace Messiter Tunnel on the Canadian National Railways

By R. D. MILES

P. Geol., Soils Engineer, Mountain Region, Canadian National Railways, Edmonton, Alberta

Messiter Tunnel was located on Canadian National Railways' main line to Vancouver, about 12 miles south of Blue River, B. C., on the steep west slope of the North Thompson River valley. Many problems were faced in daylighting Messiter Tunnel, including maintaining normal traffic, disposal of excavated material in the North Thompson River in cooperation with the Fisheries Commission, and finding a method to excavate extremely sensitive semi-liquid silt that made up the major part of the over-burden over the tunnel.

The project was carried out under direction from the office of E. S. English, regional engineer, CNR, Edmonton, and the author maintained liaison with the project from the Edmonton office.

History of the Tunnel

Messiter Tunnel was 417 ft long. It was constructed of timber in 1916, and lined with concrete in 1917 and 1918. A large number of weepholes were built into the concrete lining to handle seepage water, but these were plugged soon after construction to reduce the icing they caused.

Despite the addition of 80 ft of tunnel liner plate in 1954 and a system of horizontal drains drilled in from the portals in 1962, the concrete lining continued to deteriorate badly.

The first attempt to daylight the tunnel in 1950 ended in failure when excavation equipment became bogged down in the saturated silt. Nevertheless, about 60 ft of sand and silt were removed from over the tunnel. In 1963 it was decided to try again, this time after a test boring program and consulting study. Both portals were reinforced with bent sections of 80-lb rail to prevent possible collapse during the daylighting operations.

Geology and Soils

The site of the tunnel is shown in Fig. 1. The river flows in its old pre-glacial channel to just east of the tunnel where it is diverted southward through a deep, narrow, rock gorge and then returns to its old channel just west of the tunnel. The old

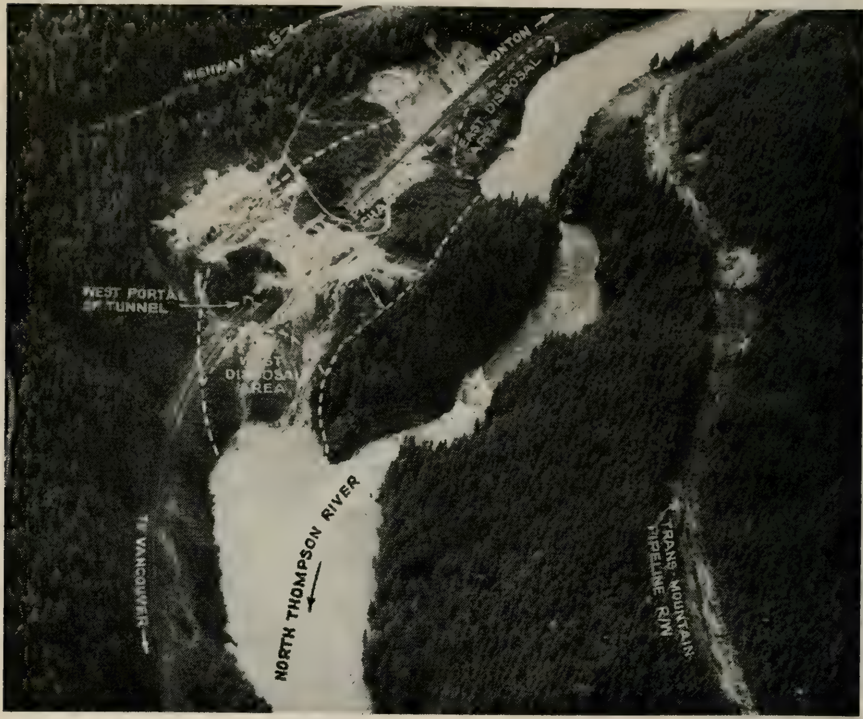


Fig. 1—Air view of Messiter Tunnel area.

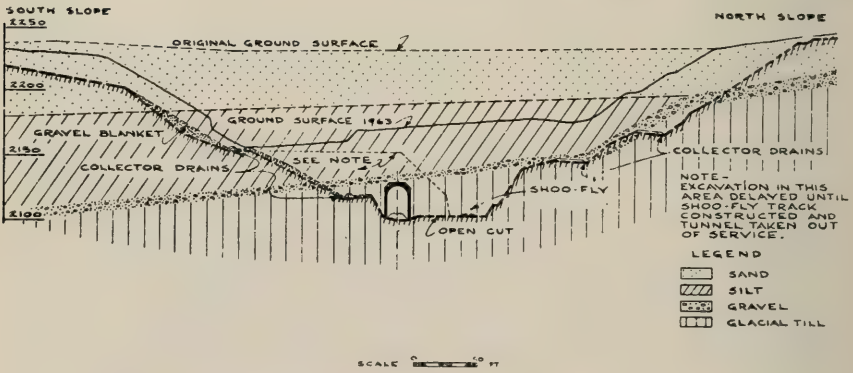


Fig. 2—Section through open cut at tunnel mid-point.

river channel is filled with glacial deposits including till, sand and gravel and glacial lake silts. The tunnel was driven through these deposits. Fig. 2 is a typical cross section of the materials in the vicinity of the tunnel. The soils involved in the daylighting operations are described as follows.

Sand

A thick layer of clean sand originally capped the area. It presented no problems in excavation and was graded to stable slopes of 1½ horizontal to 1 vertical.

Silt

Underlying the sand is a silt formation of glacial lake origin. The silt was not highly loaded in its past history and is stratified with thin layers of water-bearing fine sand, making it susceptible to the development of high pore pressures. These factors make the silt extremely unstable and subject to complete loss of strength, or "quicking," on disturbance. This silt deposit starts under the north slope and was 50 ft thick over the tunnel. Slopes in the silt were designed at 2:1.

Sand and Gravel

Below the silt is a thin layer of sand and gravel, varying in thickness from a few to 15 ft. This stratum carried most of the subsurface water which was thought to have been the main cause for deterioration of the tunnel lining.

Glacial Till

Underlying the sand and gravel is hard glacial till. The surface of the till intersected the tunnel structure at about the spring line. The till was relatively impervious and very hard and had to be loosened by ripping before loading into scraper units.

Excavation of Open Cut

The work started in mid-May 1963 and included the excavation and disposal of approximately 300,000 cu yd of material, demolishing and disposing of the tunnel and installing the necessary drainage.

The contract was set up as a two-year project on account of:

(1) Problems in handling the sensitive silt.
(2) Limited time period of March 1 to June 30 for disposal of material directly into the river, as set down by the Fisheries Commission.
(3) Limited disposal areas as a result of (2).

The job was specified to proceed in stages to eliminate unnecessary risks to railway traffic. The first year's work was to include excavation of about 20 ft of silt and construction of collector drains on benches on both slopes. The second year's work was to include completing the excavation, dismantling and disposing of the tunnel and completion of all drainage facilities.

The contractor's initial job was to cut off most of the water draining into the excavation area from the mountain above by building an interception ditch. A number of shallow drill holes were put down first to ensure that the ditch would bottom out in the relatively impervious glacial till.

Excavation commenced in the sand on the north slope, using three 20-cu-yd scrapers, three large bulldozers and a ⅝-yd dragline. The contractor used the sand advantageously for building haul roads over areas where the silt was exposed and constructing a dike along the river at the east end of the tunnel. The area between the dike and the railway grade was used for disposal of the silt after the June 30 deadline for depositing material in the river. Grade crossings were used by the contractor at both ends of the tunnel to keep loaded scrapers from traveling over the tunnel and the silt. To ensure the safety of the track, radio-equipped flagmen coordinated train traffic with the contractor's operations.

The sand excavation on the north slope was carried out efficiently, exposing the glacial till as expected. On the assumption that most of the seepage water from above would flow along the top of the till, a 12-in asphalt-coated interception drain was installed along the sand-glacial till contact throughout the length of the excavation.

At the same time, on the south slope, the sand and silt were excavated down to the length of the top bench and collector drain. Silt on the south slope was covered with 2 ft of sand-and-gravel filter blanket. Benches were provided with perforated pipe drains and blanketed with 1 ft of filter blanket. The sand and gravel on top of the south slope was suitable for the filter material.

Although it was expected that draglines and sluice-ways might have to be used to excavate the silt, the careful operation of tractor-drawn scrapers was successful. Drainage of the excavation area was well maintained and equipment was only operated on the silt during dry periods. Other materials were excavated during periods of rain.

During the period from June 5 to 30, the contractor hauled about 50,000 cu yd of silt to the west disposal area in the river. The site as it appeared at this time is shown in Fig. 3. During July the contractor commenced hauling excavated silt to disposal behind the dike at the east end of the tunnel.

About August 1 the contractor realized that this east disposal area would not hold all of the silt. As there was no other area available and the first year's phase of excavation as set down in the contract was completed anyway, he considered suspending operations until the following spring.

However, in discussion with the railway engineers, he felt that if the remaining silt could be disposed of, the daylighting could be completed before freezeup.

At this point the railway suggested use of a work train to haul the silt to acceptable disposal areas which lay within a mile of each end of the tunnel. This idea was accepted and with the contractor loading the silt, the work train hauled an estimated 25,000 cu yd of silt in 18 days' time. Fifteen air dumps, a spreader and two diesel units were used.

Excavation Adjacent to Tunnel

As the excavation progressed, more concern was given to the safety of the tunnel. It was stated in the contract that no heavy equipment would operate closer than 30 ft directly above the roof of the tunnel while it was in service. Below this level, excavation was to be done by dragline, casting to scrapers on each side. During excavation by dragline, two sinkholes developed directly above the tunnel. The largest of these was about 10 ft in diameter and 8 ft deep. As the tunnel was still in use, all work in the vicinity was immediately stopped. Ground cracks were found running parallel to the tunnel. It was concluded that large voids must have existed behind the concrete lining, either as a result of original construction or as a result of erosion by the seepage water. Evidently the soil had arched over these voids until disturbed by excavation.

In view of the danger to train traffic, it was decided not to excavate further over the tunnel but to immediately start on the shoo-fly excavation to the north and get the shoo-fly into operating condition as soon as possible. This modification required only minor slope revisions and slightly increased yardage. Careful daily measurements on the concrete lining showed no movement, and after several days all movement of the silt in the area of the sinkholes stopped.

Drainage systems for the project were set out in the specification so that changes could be made when the excavation was opened. This provision was useful, as the top

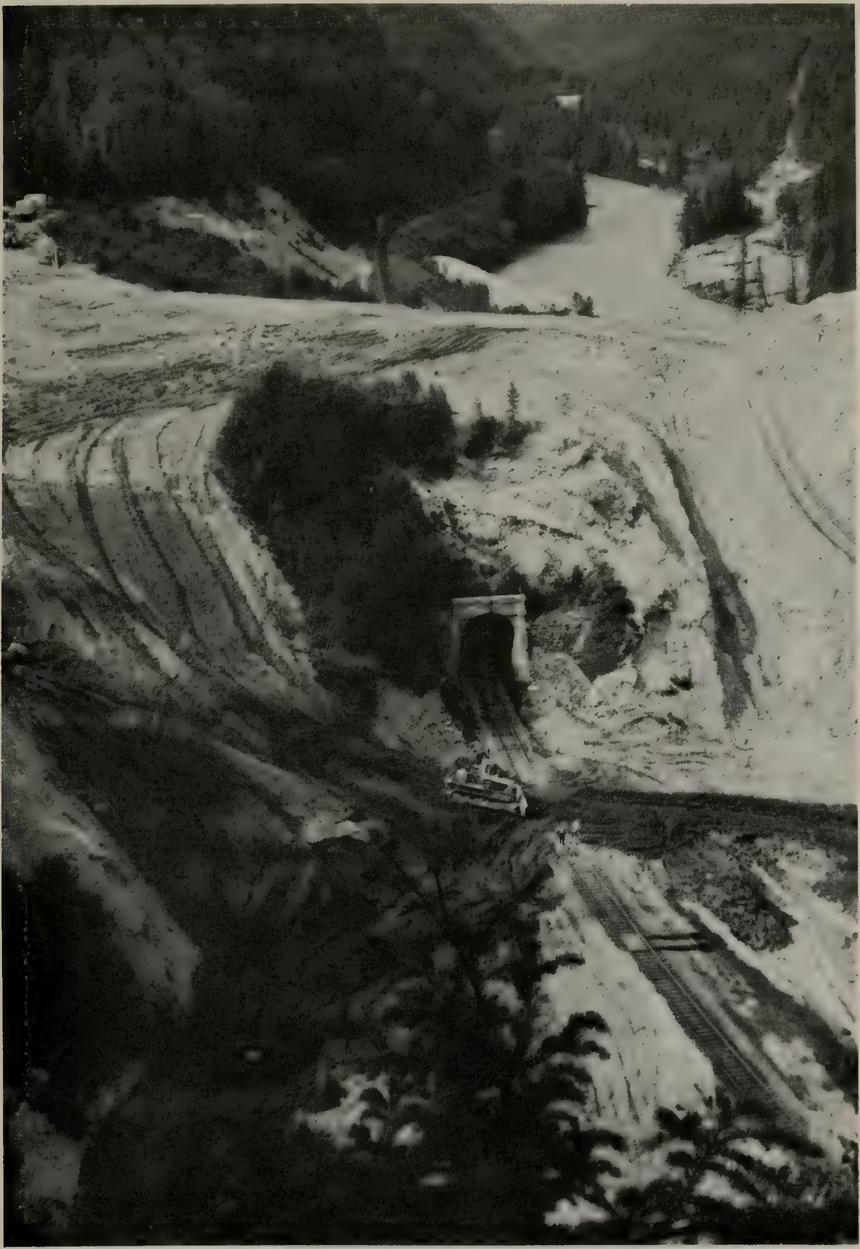


Fig. 3—June 1963. View of tunnel during excavation, with west portal in foreground.

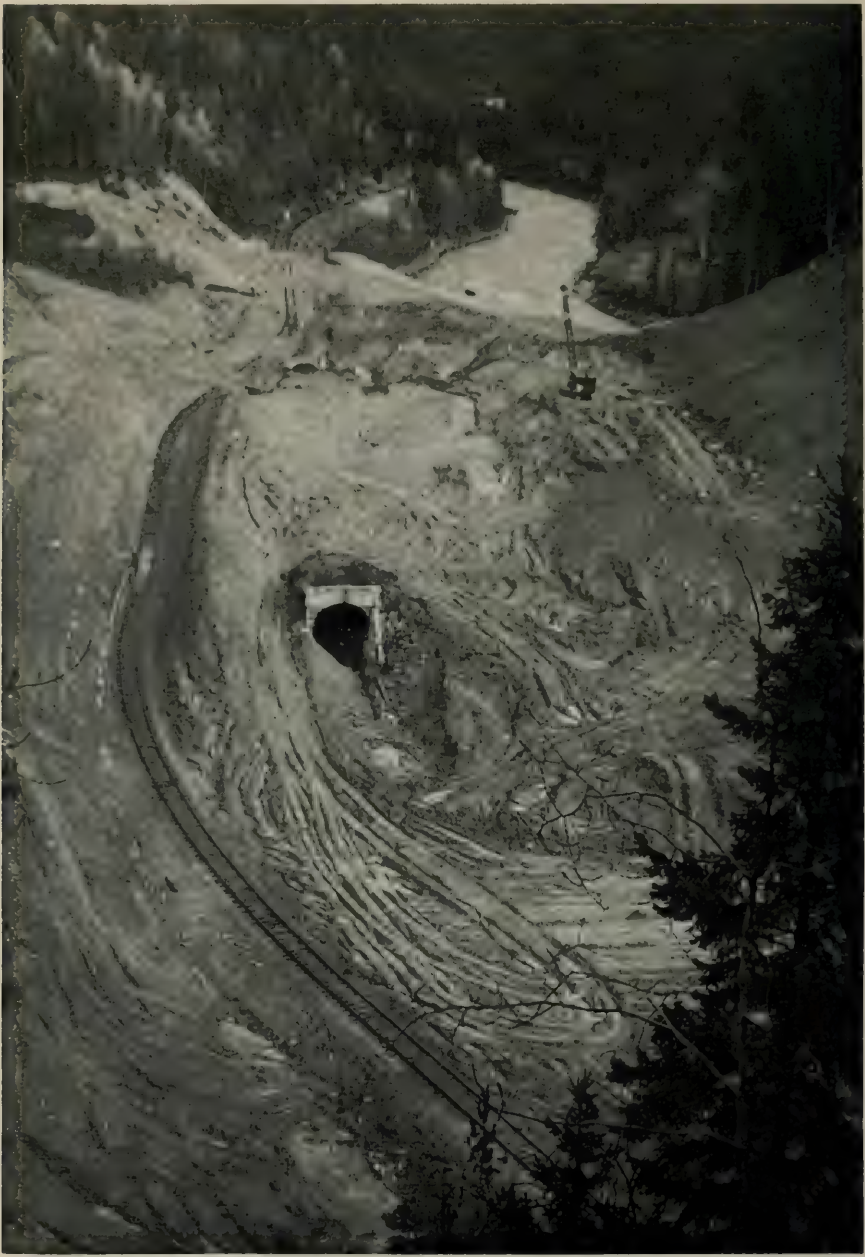


Fig. 4—October 1963. View of shoo-fly excavation, with west portal of tunnel in foreground.

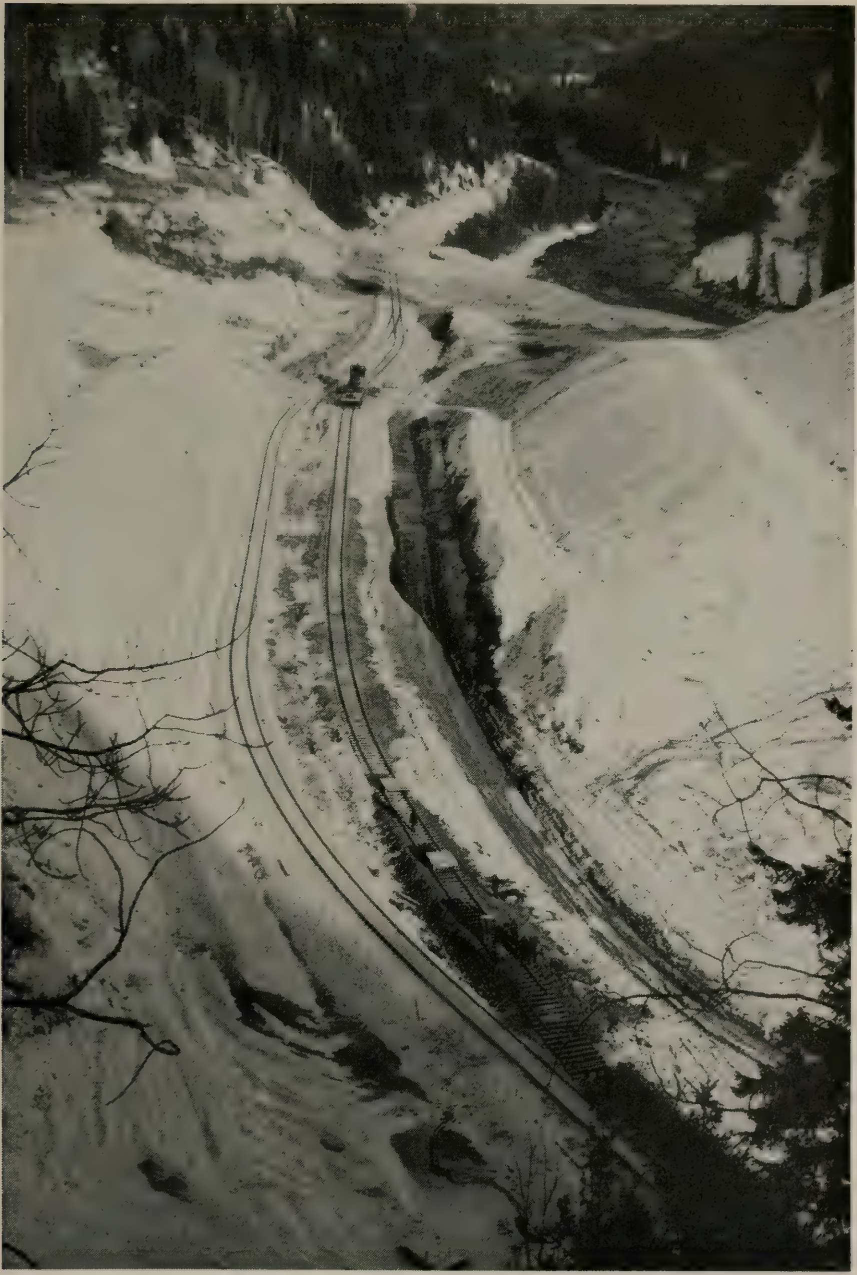


Fig. 5—December 1963. View of completed excavation with temporary trackage.

of the glacial till layer proved to be quite variable. As a result several minor drainage revisions were required.

The shoo-fly was completed on October 1, as shown in Fig. 4, and excavation was resumed on the material surrounding the tunnel.

This work progressed slowly because of the need for careful disposal. Throughout the operation no damage occurred to the lining of the tunnel and no further movements occurred, although scrapers were used to within 15 ft of the top of the tunnel.

Dismantling of Tunnel

By October 18, a large portion of the concrete lining was exposed and was demolished by explosives. Placing of explosives and delays was controlled to ensure that shock waves would not initiate movements in the slopes, or disposal areas. The broken pieces of concrete lining were used around the edge of the west disposal area along the river to reduce erosion.

The excavation was taken to grade during the first week of December, as shown in Fig. 5. Because of the onset of cold weather, relocation of the shoo-fly track to final alignment was postponed until the spring of 1964, when permanent ditches were also finished and all slopes seeded to reduce erosion. Slopes performed well during the spring breakup.

Conclusion

The project clearly emphasizes the importance of thorough preliminary investigation and planning of all aspects of a job of this type. Of equal importance is the correlation of all information available between parties concerned. Close field supervision paid valuable dividends, along with allowances for adjusting drainage and other phases of the design as the exact site conditions were exposed.

Report on Assignment 9

Roadway Signs

(a) Reflectorized and Luminous Roadway Signs, Collaborating with Committees 5 and 9, and with the Communication and Signal Section, AAR
(b) Shop Layout for Production of Roadway Signs

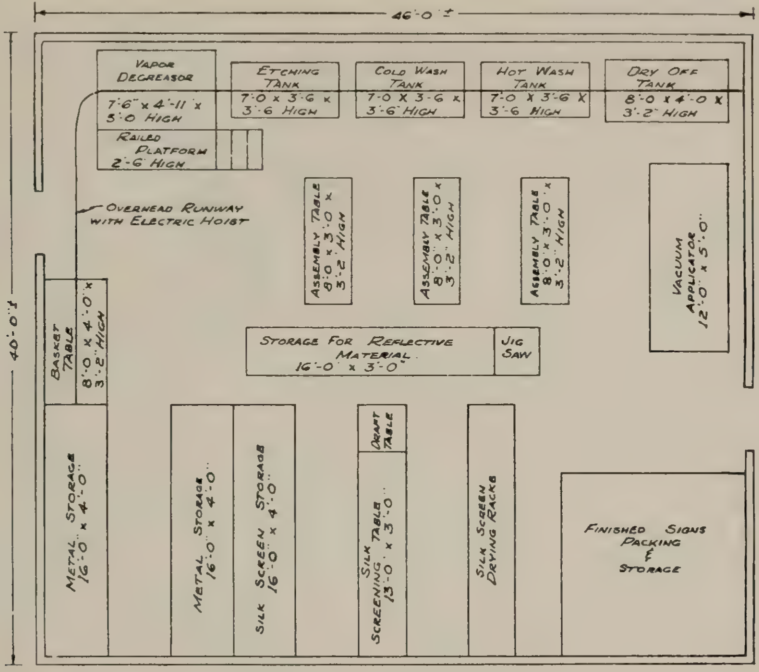
R. D. Baldwin (chairman, subcommittee), A. S. Barr, R. J. Kemper, R. D. White, Paul McKay.

Your committee reports on Assignment (b) only, as information.

The accompanying illustration portrays a shop layout for the production of roadway signs which the committee feels represents the most desirable features of shops in use on several railroads. It should be noted that the layout is offered as a guide and can be dimensionally changed to suit local conditions.

The shop layout involves the following processes:

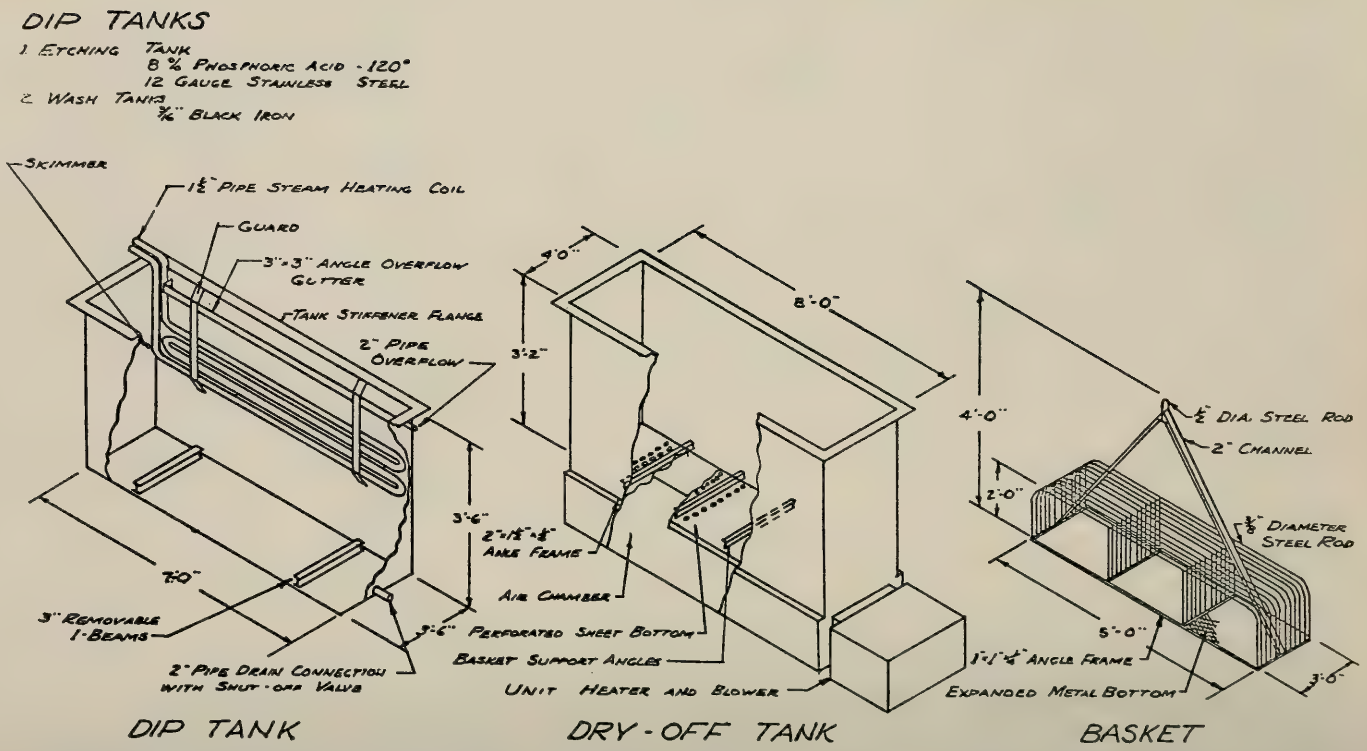
1. Pre-cutting aluminum background in a metal shop and stocking in metal storage inside shop.
2. Degreasing aluminum in vapor degreaser.
3. Etching aluminum backing.


46'-0" ±
40'-0" ±
Vapor Degreasor 7'-6" x 4'-11" x 5'-0" High
Etching Tank 7'-0 x 3'-6 x 3'-6 High
Cold Wash Tank 7'-0 x 3'-6 x 3'-6 High
Hot Wash Tank 7'-0 x 3'-6 x 3'-6 High
Dry Off Tank 8'-0 x 4'-0 x 3'-2" High
Railed Platform 2'-6" High
Overhead Runway with Electric Hoist
Assembly Table 8'-0 x 3'-0 x 3'-2" High
Assembly Table 8'-0" x 3'-0" x 3'-2" High
Assembly Table 8'-0 x 3'-0 x 3'-2" High
Vacuum Applicator 12'-0" x 5'-0"
Basket Table 8'-0 x 4'-0 x 3'-2" High
Storage for Reflective Material 16'-0" x 3'-0"
Jig Saw
Metal Storage 16'-0" x 4'-0"
Metal Storage 16'-0" x 4'-0"
Silk Screen Storage 16'-0" x 4'-0"
Draft Table
Silk Screening Table 13'-0" x 3'-0"
Silk Screen Drying Racks
Finished Signs Packing & Storage

NOTE:
ALL DIMENSIONS ARE SUGGESTED AND SHOULD BE VARIED TO ACCOMODATE AVAILABLE SPACE

Shop layout for the manufacture of roadway signs, using reflective material.

4. Cold rinsing.
5. Hot rinsing.
6. Drying aluminum backing.
7. Application of reflective material to aluminum backing in vacuum applicator.
8. Application of lettering, using silk-screen process or by applying pre-cut adhesive letters in the vacuum applicator.



Typical dip tank, dry-off tank and basket for the preparation of aluminum for application of reflective material.

Report on Assignment 10

Ballast

(a) Tests
(b) Special Types of Ballast

T. W. Creighton (chairman, subcommittee), E. W. Bauman, R. H. Beeder, D. L. Bloem, J. G. Campbell, J. E. Gray, W. C. McCormick, N. B. Roberts, E. L. Robinson, Jr., E. L. Woods.

In Bulletin 584, February 1964, pages 508 to 510, incl., recommended ballast sections and ballast quantity graphs were presented as information with the request that members of the Association offer comments and criticisms. Since no comments or criticisms were received, your committee submits this material for adoption and publication in the Manual. The specific recommendations of your committee are as follows:

Pages 1–2–6 to 1–2–12, incl.

BALLAST SECTIONS FOR SINGLE AND MULTIPLE TRACK ON TANGENTS AND CURVES

Delete, substituting therefor the ballast sections appearing on pages 509 and 510 and the ballast quantity charts, Graphs 1 to 4, incl., following page 510, in Bulletin 584, February 1964.

Report on Assignment 10 (b)

Special Types of Ballast

Asphalt Treatment of Ballast and Bridge Decks—1964 Inspection

This report describes the 1964 condition of the asphalt-treated ballast test sections and asphalt bridge-deck treatments applied in 1959 and 1960. All of these test sections were inspected during the summer of 1964 by representatives of the Asphalt Institute and the Association of American Railroads Research Department. In addition, the railroads involved have supplied maintenance cost records for both the test sections and adjacent control sections.

1959 BALLAST TREATMENTS

Santa Fe Railway

Daggett–Barstow, Calif.—This 2-mile test section on volcanic-cinder ballast was treated in 1959 with 85/100 penetration asphalt cement applied at the rate of 1.38 gal per sq yd followed by a spread of cover aggregate at the rate of 20.3 lb per sq yd. The condition of this test varies from fair to good. There is little apparent change in the two-mile test track since the last inspection in 1962.

Some disturbance in the form of pushing up of treated ballast between the ties and loose ballast in the cribs was noted. The line and surface have, however, apparently remained good. The adherence of the asphalt to the ties is generally good. No maintenance has been required on the test section since the previous inspection, whereas a nominal amount has been required on the adjacent control section.

Again, as during the previous inspection, it is apparent that better results could have been obtained if the quantity of asphalt applied had been somewhat greater.

Peach Springs–Truxton, Ariz.—This 5.2 mile section of track on volcanic cinder ballast was treated in 1959 with 85/100 penetration asphalt cement at the rate of 1.18 gal per sq yd followed by cover-coat aggregate spread at the rate of 22 lb per sq yd. As during the previous inspection, considerable disturbance of the asphalt-treated ballast in the cribs and at tie ends was noted. The occasional pumping evident in the previous inspection has continued at about the same rate and frequency. The line and surface appear to be generally good. The asphalt coating on the ties remains fair to good.

A relatively small amount of maintenance in the form of lining and surfacing has been required on the test section since the last inspection. No maintenance has been required on the control section over the same time period. The total maintenance cost for this test section from the time of installation to date has run about 45 percent of that for the adjacent control track although it has been relatively low for both.

Not much change is apparent in the condition of the test section since the last inspection. Insufficient asphalt was applied to properly penetrate and cement the ballast. The level of the ballast on the shoulders is too high with respect to the ballast in the cribs to allow for efficient drainage. These points were also noted in the 1962 condition report.

Lecomption–Topeka, Kans.—This test section, which is 4 miles in length, is ballasted with coarse chat except for a ¾-mile stretch which was given a final surface of fine chat. The average application of 120/150 penetration asphalt cement was at the rate of 1.29 gal per sq yd over the coarse chat and ¾ gal per sq yd over the fine chat. The cover aggregate was fine slag averaging 19.4 lb per sq yd for the entire treatment. As mentioned in the 1962 condition report, a one-mile stretch of this asphalt-treated-ballast test section was removed in 1961 and the track was relined and resurfaced. This one-mile sretch was in an area of chronic instability along a river. In 1963 an additional 1.1 miles of the asphalt-treated ballast test was dug out and resurfaced. This too was in an area of chronic instability. In addition to this there has been considerable spotting on another mile of the treatment which was chiefly in the area of fine chat ballast.

Approximately ½ mile of asphalt-treated track at each end of the test remains completely intact. The treatment in these areas appears to be in good condition except for some cracking on the shoulders and dishing in the center. This condition can probably be attributed to the fact that the asphalt treatment was applied almost immediately after surfacing rather than allowing a shake-down period of 3 to 6 months during which the ballast could settle and be redressed before treatment with the asphalt. These two ½-mile stretches of asphalt-treated ballast do not have the unstable, wet subgrade conditions that exist in most of the other areas originally treated with asphalt in this test section.

The control section for this test, which is the four miles of track immediately preceding the four-mile test track, has been spotted in its entirety twice since the installation of the test section. It is unfortunate that the control section does not parallel the test section. It does not allow a fair comparison because of the variation in subgrade stability between the test and control sections.

Bucklin–Marceline, Mo.—This 4.15-mile test was installed on slag ballast in 1959 with the application of 85/100 penetration asphalt cement at the rate of 1.34 gal per sq yd followed by a cover coat of gravel screenings spread at the rate of 33.4 lb per sq yd. The general condition of this test section is still very good. The test track, for the most part, is holding line and surface very well. There is a relatively small amount of pumping, and some stretches have required minor spotting since the 1962 condition inspection.

The treatment is in good condition. The asphalt is still alive, the cribs are relatively tight and the asphalt coating is adhering well to the ties.

A short section of the asphalt-treated ballast was dug out in connection with the installation of a cross-over and the asphalt was found to have penetrated below the bottoms of the ties.

The maintenance costs for both the treated track and the adjacent control track are very small and are about equal since the 1962 inspection.

Victorville and Oro Grande, Calif.—In 1959 a total of 2 miles of track at Victorville and 2.5 miles of track at Oro Grande was treated by applying 120/150 penetration asphalt cement followed by crushed gravel screenings. These sections of track were treated to prevent dust from adjacent cement mills from fouling the crushed-gravel ballast, and were not intended as test sections. The eastbound and the westbound tracks were treated at both locations in 1959.

In 1963 the eastbound tracks at both Oro Grande and Victorville were dug out and skin lifted through the test area to correct irregularities in surface. It is the judgment of the railroad personnel that these irregularities, for the most part, were already present when the asphalt treatment was applied in 1959 and did not occur subsequent to treatment.

The westbound asphalt-treated tracks at both locations are about the same as noted in the 1962 inspection. A small amount of spotting has been required, but the cribs are generally tight. There is a minimum amount of disturbance at tie ends, and there is excellent adherence of asphalt and cover aggregate to the ties and track fittings.

Williamsfield–Dahinda, Ill.—This test on 3.5 miles of limestone-ballasted track was installed in 1959 with the application of 85/100 penetration asphalt cement at the rate of 1.24 gal per sq yd followed by gravel screenings spread at the rate of 28.9 lb per sq yd. The test section remains in excellent condition. Very little change was noted since the 1962 inspection. The cribs are generally tight, the adherence of the cover aggregate is good, the asphalt coating on the ties is excellent, and the line and surface have apparently remained good. There may be a slight amount more disturbance at the tie ends than in 1962 and a small amount of longitudinal tie movement is evident.

The maintenance costs for the test track are negligible and no maintenance has been required on the adjacent control track since the 1962 inspection.

1960 BALLAST TREATMENTS

Norfolk & Western Railway

In 1960 this 2.8-mile stretch of track on limestone ballast was treated by applying 85/100 penetration asphalt cement at the rate of 1.37 gal per sq yd followed by a cover aggregate of limestone screenings spread at the rate of 26 lb per sq yd.

This test section is still in generally excellent condition. The cribs are tight and the asphalt has adhered well to the ties, the base of rail and the fittings. The line and surface have apparently remained excellent.

Exceptions occur at grade crossings where 6 to 12 ties on both sides are pumping under wet conditions. The pumping material appears to be mostly coal dust, but the condition is severe enough to destroy the asphaltic bond, permitting water an easy entrance.

A nominal amount of maintenance has been required on the control section since the last inspection. No maintenance has been required on the test section.

Monon Railroad

This 4.8-mile limestone-ballasted test section was treated in 1960. Approximately one mile was sprayed with 120/150 penetration asphalt cement and the remainder with 85/100 penetration asphalt cement applied at the rate of 1.25 gal per sq yd. A cover-coat of limestone screenings was spread at the rate of 25 lb per sq yd.

The test track is still in excellent shape. The cribs are tight, the ballast section is well crowned for good drainage, the asphalt and cover aggregate are adhering well to the ties and the line and surface appear to be excellent.

Two miles of the test section has continuous welded rail while the remainder has jointed rail. The section on jointed rail exhibits more tie movement but is still generally in very good condition.

No maintenance has been required on either the test section or the adjacent control section since treatment.

Texas & Pacific Railway

Two sections of track near Big Spring, Tex., each two miles in length, were treated with asphalt cement in 1960. The 85/100 penetration asphalt cement was applied at the average rate of 1.04 gal per sq yd followed by rock screenings spread at the rate of 25 lb per sq yd. Control sections are at both ends of each of the two test sections.

The west two-mile test section is still in very good condition. The cribs are tight, line and surface are good, and the adherence of the asphalt and cover aggregate to the ties is excellent. There is a small amount of pumping, chiefly at the joints. The ballast on the shoulders has settled in a few places, but this apparently has not hurt the treatment or affected line and surface. The west test section has required no maintenance since the asphalt application. The control section for the west test section is in good condition but required some maintenance in 1963 and 1964.

The east two-mile test section became quite rough in 1963 and considerable maintenance in the form of spotting and lining was required that year. Most of the spotting was at the joints on the ¾ miles at the west end. Some pumping, chiefly at the joints, was noted at the time of the inspection. The control section for the east test section has also required some spotting and lining in 1963 and 1964 but not as much as the test section.

Chicago & North Western Railway

In 1960, 1.6 miles of the quartzite-ballasted track on the Chicago & North Western Railway near Melrose Park, Ill., was treated with asphalt. The 120/150 penetration asphalt cement was applied at an average rate of 1.52 gal per sq yd followed by quartzite screenings spread at the rate of 21 lb per sq yd.

At the time of the 1964 inspection, the condition of the asphalt treatment was fairly good. The cribs were tight, but there was evidence of disturbance at the tie ends. The adherence of the asphalt to the ties was good. The control section on the westward main had developed a few minor rough spots and was given a skin lift in 1964. The test section on the eastward main was in comparable condition and will receive a similar skin lift in the spring of 1965.

Asphalt-treated bridge deck at time of 1964 inspection.

1959 AND 1960 BRIDGE DECK TREATMENTS

Pittsburgh & West Virginia Railway

In 1959, 12,780 lin ft of bridge decks were treated on the Pittsburgh & West Virginia Railway with the application of 60/70 penetration asphalt cement at the average rate of 1.37 gal per sq yd followed by a cover spread of slag at the average rate of 33 lb per sq yd. In 1960, an additional 12,990 ft of open-deck bridges were treated with 60/70 penetration asphalt cement applied at the average rate of 1.29 gal per sq yd followed by slag screenings spread at the average rate of 34.6 lb per sq yd.

The 1964 inspection of asphalt-treated bridges showed no apparent changes since the previous inspection in 1962. The coating on ties is generally very good. The asphalt and cover aggregate are still adhering well to the track fittings and base of rail on those bridges treated in 1960 and poorly to these metal surfaces on the bridges treated in 1959. As stated in previous reports the metal surfaces were primed with a kerosene spray prior to the 1960 applications but not prior to the 1959 applications. Also, as noted previously, the bridges which received two directional applications applied at slower speeds show better filling of cracks and checks in the ties.

Some of the bridges were only partially treated, leaving control sections of untreated ties. These untreated ties generally exhibit considerably more checking and cracking than is apparent on the adjacent treated ties.

No maintenance has been required on either the treated sections or untreated control sections since the 1962 inspection.

Another asphalt-treated bridge deck at time of 1964 inspection.

Chicago Rock Island & Pacific Railroad

In 1960, a number of open-deck bridges in Arkansas and Louisiana were treated with 85/100 penetration asphalt cement applied at the rate of approximately 1 gal per sq yd. The asphalt application was followed by a spread of chat screenings on some of the bridges. In all, 36,325 lin ft of bridges were treated at an average cost of 42.9 cents per tie.

Some bridges were only partially treated, leaving a portion untreated for a control section.

It is apparent that the treatment has served excellently in filling cracks and splits in the ties. Large open splits and cracks are in evidence on the untreated ties in contrast to smaller, well filled splits and cracks on the treated ties. The asphalt and cover aggregate, where used, have adhered well to the base of rail and to track fittings.

An increased tie life of one year will more than pay for the cost of treatment. Indications are good that the average increase in tie life on the treated bridge will greatly exceed this.

There have been no maintenance expenditures on either the treated test sections or untreated control sections since the 1960 asphalt applications.

TABLE of MAINTENANCE COSTS for ASPHALT TREATMENT

Ballast Treatments

Railroad	Location of Test Section	Length of Test	Year Treated	Kind of Ballast	Asphalt Cement		Cost of treatment mile	Cost of Maintenance to Aug. 1962 (cost/mile)		Cost of Maintenance Aug. 1962 to Aug. 1964 (cost/mi)	
					Penetration Grade	Gal. per sq. yd.		Test Sec.	Control Sec.	Test Sec.	Control Sec.
AT & SF	Daggett-Barstow California	2 mi.	1959	Volcanic Cinders	85-100	1.38	$1080.39	$379.04	$268.92	0	$215.86
AT & SF	Peach Springs – Truxton, Arizona	5.2 mi.	1959	Volcanic Cinders	85-100	1.18	$1014.75	$ 78.13	$180.31	$ 0.85	0
AT & SF	Lecompton – Topeka Kansas	4 mi.	1959	Chat "B" Fine Chat	120-150	1.29	$1008.81	$991.78	$1440.39	$846.67	0
AT & SF	Bucklin – Marceline, Missouri	4.15 mi.	1959	Slag	85-100	1.34	$ 945.54	$105.07	$ 316.15	$ 13.31	$ 13.31
AT & SF	Williamsfield – Dahinda, Illinois	3.5 mi.	1959	Limestone	85-100	1.24	$ 879.70	$ 91.18	$170.20	$ 6.60	0
AT & SF	Victorville, Cal. & Oro Grande, Cal.	4.5 mi.	1959	Crushed Gravel	120-150	1.75 to 2.0	$ 983.58	$640.67	No Control Section	*$751.11	No Control Section
	(*Note: Work consisted of digging out & skin lifting through the test area on both eastward asphalt treated tracks)										
N & W Ry.	Crewe, Virginia	2.8 mi.	1960	Hard Limestone	85-100	1.37	$1204.68	0	$423.21	0	$ 86.07
Monon	Monon, Indiana	4.8 mi.	1960	Limestone	85-100 & 120-150	1.25	$ 975.00	0	0	0	0
T & P	Big Spring, Texas	4.0 mi.	1960	Crushed Rock	85-100	1.04	$1164.50	$ 5.50	$ 55.50	$724.05	$416.62
C & NW	Melrose Park, Illinois	1.6 mi.	1960	Quartzite	120-150	1.52	$1384.91	0	0	0	$378.00
	Bridge Deck Treatments										
P & W Va.	Pennsylvania	12,780 lin. ft.	1959		60-70	1.37 gal. per sq. yd.	52.7¢/ tie	$280.00 (Tot. Cost)	0	0	0
P & W Va.	Pennsylvania	12,990 lin. ft.	1960		60-70	1.29	45.2¢/ tie	0	0	0	0
CRI & P	Arkansas & Louisana	36,372 lin. ft.	1960		85-100	1.0	42.9¢/ tie	0	0	0	0

Report on Assignment 11

Chemical Control of Vegetation

Collaborating with Communication and Signal Section, AAR

D. H. Yazell (chairman, subcommittee), C. W. Bailey, R. J. Bruce, J. W. DeMoyer, S. J. Owens, T. S. Stone, T. J. Hernandez, J. P. Taylor, J. R. Sterling.

Your committee presents its report on Assignment 11 in two parts, both as information. Part 1 is a report covering the weed-control seminar held in Chicago on October 6–7, 1964. Part 2 is a report on helicopter spraying on railroad right-of-way.

Part 1—Report on Weed-Control Seminar Held in Chicago, October 6–7, 1964

In 1963 the committee requested the Research Department, AAR, to resume holding vegetation control conferences and the AAR allocated suitable funds for this purpose in 1964. Such a meeting was held in Chicago on October 6–7.

For the first day, attendance was limited to railroad personnel plus three weed-control specialists—a professor of agronomy, an extension agronomist from the University of Illinois, and the supervisor, Section of Weed Control, Department of Agriculture, State of Minnesota. Total attendance for the day was 56. This same group met the second day with representatives of chemical companies and applicators. Total attendance for that day was 96.

With the exception of talks by the specialists, the meeting on both days consisted of panel discussions with each panelist first giving a short talk. Fields covered included the various types of hormone materials, state regulations, noxious weeds, legal enforcement practices, methods of application for brush and weeds, railroad research procedures, and planned programs involving long-range rotations in chemicals. There were further discussions on the development of new products, dry applications versus solutions and design of equipment, and nonchemical methods and their place in desired control.

It is possible that future conferences will be held at two- or three-year intervals

Part 2—Helicopter Spraying on Railroad Right-of-Way

Helicopters for applying vegetation control chemicals have been used experimentally by several railroads.

One of the simplest and most reliable yardsticks for measuring the benefits of an application method is to compare its costs and results with previous or other methods If the use of a helicopter can give lower application costs or superior results, then its use can be justified. But lower costs must not mean inferior results and higher costs must be offset by measurably superior benefits.

Since railroads already have a good "highway" down the center of the right-of-way, it is difficult for any method of application which relies on a non-rail mode of transportation to compete economically.

The helicopter is limited in the amount of pay load it can successfully carry and spray. Altitude and heat materially affect the pay load. The method most used by helicopter applicators to offset high costs is to use a more concentrated chemical. This is commonly called "low-volume" spraying.

Low-volume helicopter spraying has had a limited success in brush control—generally on certain brush species and in very rugged terrain where operations of fixed-wing aircraft are hazardous. Aircraft is used extensively on utility rights-of-way where rugged terrain, mountainous and hilly conditions are encountered.

If the low-volume sprays are effective in helicopter spraying, then why not use them in spraying from the track and further reduce the costs of on-track spraying? Here again, we come back to our original yardstick—which method is the more economical?

One factor which may affect the cost of on-track spraying is the density of traffic, which, on a high-density railroad, may mean very low track occupancy. This may raise costs so high as to make helicopter operation seem cheaper. However, there are few, if any, railroads on which 2 or 3 hr of track occupancy cannot be realized during daylight hours.

Helicopter spraying is absolutely dependent on the absence of wind. Any wind of 5 mph or more will necessitate cessation of helicopter spraying because of drifting, except where granules or invert emulsions are used. Even in a "no-wind" condition, the pilot must allow for drift around curves. Where exact widths are desired on roadbed or ballast, the slightest wind will affect the pattern. A good pilot can apply a pattern very accurately and at uniform rates under ideal application conditions.

A location where helicopter spraying can be economical on railroads is in mountainous, rough terrain where on-track equipment is not able to give the desired coverage. One such location exists on a western railroad that has to maintain a 200-ft-wide firebreak on both sides of the main lines through a mountainous region. The firebreak had been maintained by a combination of hand and mechanical clearing. On-track equipment did not have the capacity to reach the required distances and heights. Fixed-wing aircraft was impractical because of curves and wire crossings at many different levels. The helicopter seemed to be the only answer, and it was used to apply a granular herbicide at a considerable saving over previous methods.

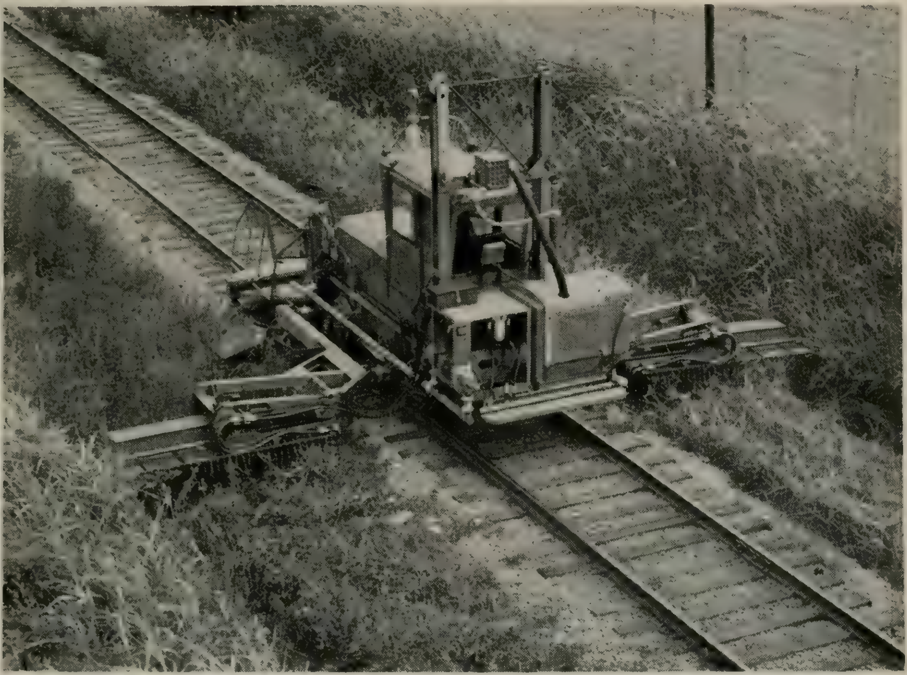
ESTIMATED COSTS, APPLICATION ONLY, PER ACRE

Work train	$2 to $ 4
Fixed-wing aircraft	$4 to $ 7
Helicopter	$7 to $11

Where thousands of acres are involved, as in Government range lands, costs for fixed-wing aircraft have been consistently quoted at less than $1 per acre, with one quotation as low as $0.60 an acre.

Determination of which method of application is the best must be decided by weighing the ultimate benefits to be gained against costs.

KERSHAW Trackwork Machines

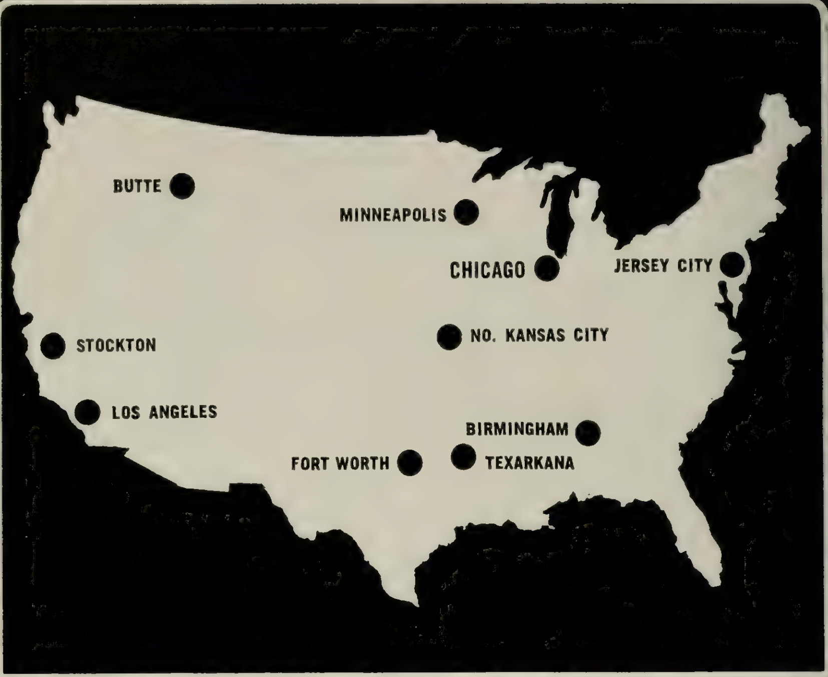


Weed And Brush Cutter (Track Patrol)
Designed, Tested, and Proven
on America's Railroads

KERSHAW
MANUFACTURING CO. INC
MONTGOMERY K ALABAMA

Trackwork Equipment Developed and Proven On the Job

Heavy Duty Ballast Regulator, Scarifier and Plow, Standard Ballast Regulator, Sacrifier and Plow, Track Broom, Super Jack-All, Standard Jack-All Kershaw Kribber, Two-Wheel Kribber, Tie Bed Sacrifier Tie Inseter, Track Undercutter-Skeletonizer, Ballast Cleaner, Crib-Adze, Mocar Crane, Track Crane and Tie Inserter, Utility Derrick, Two-Ton Rail Derrick, Tie Replacer, Dual Tie Saw, Track Liner, Snow Switch Cleaner, Weed and Brush Cutter (Track Patrol).



U.S. BORAX OFFERS COMPLETE VEGETATION CONTROL SERVICE AND PRODUCTS THROUGHOUT THE COUNTRY

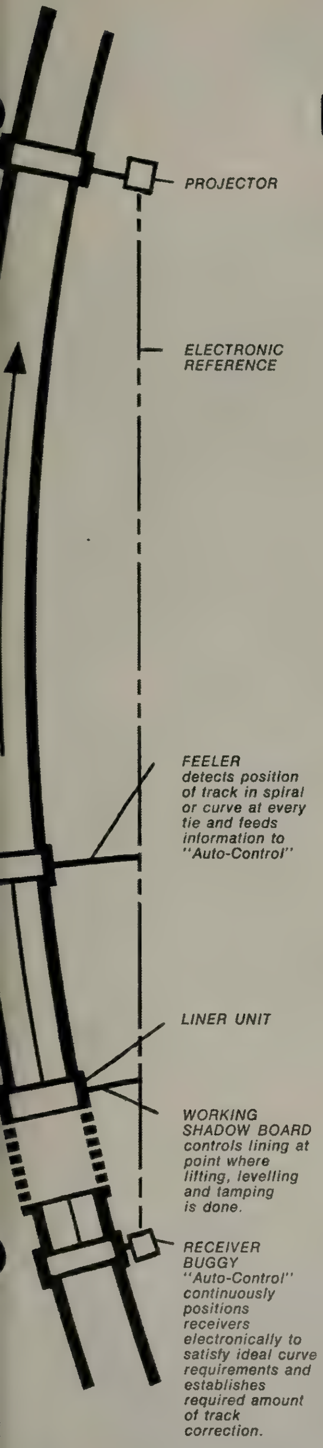
Our railroad herbicide specialists know your regional weed, soil, and weather conditions. They have an extremely wide selection of weed and brush killing chemicals. Now, with strategically located production facilities and the most efficient spray cars in railroading today, U.S. Borax is fully equipped to contract for any vegetation control program—and carry it out promptly, effectively and economically.
We would like an opportunity to prove it to you. Write today.

3456 Peterson Avenue, Chicago 45 • INdependence 3-6262

U.S. BORAX

AND STRAIGHT DOWN THE LINE WITH Tamper

AUTOLINER


PROJECTOR
ELECTRONIC REFERENCE
FEELER detects position of track in spiral or curve at every tie and feeds information to "Auto-Control"
LINER UNIT
WORKING SHADOW BOARD controls lining at point where lifting, levelling and tamping is done.
RECEIVER BUGGY "Auto-Control" continuously positions receivers electronically to satisfy ideal curve requirements and establishes required amount of track correction.

The Autoliner leads the way with the following advantages:

- Gives the highest possible degree of accuracy by electronic beam projected 100 feet in advance of where lining is taking place.
- Simultaneous lifting, levelling, lining, and tamping with one operator.
- No reduction of tamping speed with lining taking place at every tie.
- Automatic, continuous operation for both tangent and curve track.*
- No plotting of spirals or curves required. Machine computes as it runs for the best transition.
- No disturbing or humping of track — lining takes place simultaneously with lifting and tamping *ahead of tamping tools.*
- With the Autoliner, it is possible to make a minute throw and have it stay there because tamping is done in correct alignment.

*Model ALT for Tangent track and Model ALC for Tangent and Curve Track, both available as an attachment for the AUTOJACK ELECTROMATIC.

TAMPER INC.
53 Court St., Plattsburgh, N.Y.

Sales & Service:
2147 University Avenue,
St. Paul 14, Minnesota
Phone: 645-5055

In Canada: 160 St. Joseph Blvd.,
Lachine, Quebec.
Phone: 637-5531

Information on the Autoliner and Autojack Electromatic—or other track maintenance machines, is available on request.

Tamper

another development of NCG®...**LINK-BELT** teamwork in engineering and manufacture

CHECK THESE SERVICE PROVEN POINTS

- **Sturdy open-span construction—**
  for work saving feed-in;
  for picking up jointed re-lay rail; maintains best riding quality by keeping rails in original sequence for welding.
- **Positive double tie-down unit.**
- **Simplified low maintenance.**
- **Rollers life-lubricated.**
- **Hydraulically adjustable rollers and power-operated unloading equipment included.** One to six-tier units.

© 1963, Chemetron Corporation

NCG®

NATIONAL CYLINDER GAS
RAILROAD EQUIPMENT DEPARTMENT
Division of CHEMETRON *Corporation*

840 North Michigan Avenue, Chicago 11, Illinois

SPEED SWING

MODEL 441

Developed and Built
for Railroad Maintenance

180° BOOM SWING

DOES ALL JOBS!

ROOTS AND LOADS TIES

LAYING WELDED RAIL

9' WIDE TRACK CLEANING BUCKET

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
- Back Filler Blade
- Pull Drag Bucket
- 4 Cu. Yd. Snow Bucket
- Pile Hammer

Optional Attachment
Flanged Wheels, Hydraulically Controlled

PETTIBONE MULLIKEN CORPORATION

RAILROAD DIVISION
141 W. JACKSON CHICAGO 4, ILL.

*80 Years of Service
to the Railroad Industry*

AREA Publications—Price List

The following include some of the Association publications available from the secretary's office on order. Prices shown are for Members only:

	Member Price
Manual of Recommended Practice, complete in 2 volumes, including binders (first copy)	$18.00
Extra binders, each	4.50
Annual Supplements (first copy)	1.00

Separate Chapters

1—Roadway and Ballast	1.50
3—Ties	.25
4—Rail	.75
5—Track	.75
6—Buildings	1.50
7—Wood Bridges and Trestles	1.00
8—Masonry	1.00
9—Highways	0.50
11—Engineering and Valuation Records	1.25
13—Water, Oil and Sanitation Services	1.00
14—Yards and Terminals	1.00
15—Iron and Steel Structures	1.25
16—Economics of Railway Location and Operation	0.75
17—Wood Preservation	.50
18—Electricity (AAR Electrical Manual, $23.00 Complete with binder. Separate Sections available, prices on request)	
20—Contract Forms	1.25
22—Economics of Railway Labor	0.50
25—Waterways and Harbors	0.25
27—Maintenance of Way Work Equipment	0.50
28—Clearances	0.25
29—Waterproofing	0.25
Flexible-cover, loose-leaf binder for separate chapters, each	0.40

Portfolio of Trackwork Plans—119 plans, 8 sheets of specifications, 5 sheets definitions of terms, complete with leatherette cover	$12.50
Track Scale Pamphlet—109 pages, flexible cover	1.00
Federal Valuation of Railroads—87 pages, flexible cover	1.00
Instructions for Mixing and Placing Concrete—24 pages, flexible cover	0.40
Handbook of Instructions for the Care and Operation of Maintenance of Way Equipment—149 pages, hard cover	0.85
Instructions for Care and Safe Operation of Welding and Grinding Equipment—23 pages, flexible cover	0.30
Specifications for Steel Railway Bridges (fixed spans)—70 pages, flexible cover	0.75
Specifications for Movable Railway Bridges—73 pages, punched sheets	1.00

Yes, Spike, you can't tie UROX® for weed control

Tie your weed control program to effective, low-cost UROX Railroad Weed Killers. A complete line—right for *your* weed problems, *your* climate conditions, *your* application methods. One application can last up to 18 months. Smaller, follow-up "booster" applications continue control inexpensively. Write or phone.

Allied Chemical

GENERAL CHEMICAL DIVISION
P.O. Box 353, Morristown, N.J.

P. & M. PRODUCTS

- IMPROVED FAIR Rail Anchors

RAIL JOINT PRODUCTS

- Rajo Joints
- Insulated Joints
- Compromise Joints
- Fibre

MAINTENANCE EQUIPMENT PRODUCTS

- Meco Rail and Flange Lubricators
- Meco Rail Layers
- Meco Brush Cutters
- MACK Reversible Switch Point Protectors

PEERLESS EQUIPMENT PRODUCTS

- Draft Gears
- Rail Titan Batteries

IN CANADA:
The P & M Company Ltd

552AB

PRODUCTS OF PROGRESS

POOR & COMPANY
Railway Products Division 80 E. Jackson Blvd., Chicago 4, Ill.

Assure lower maintenance costs, better performance with...

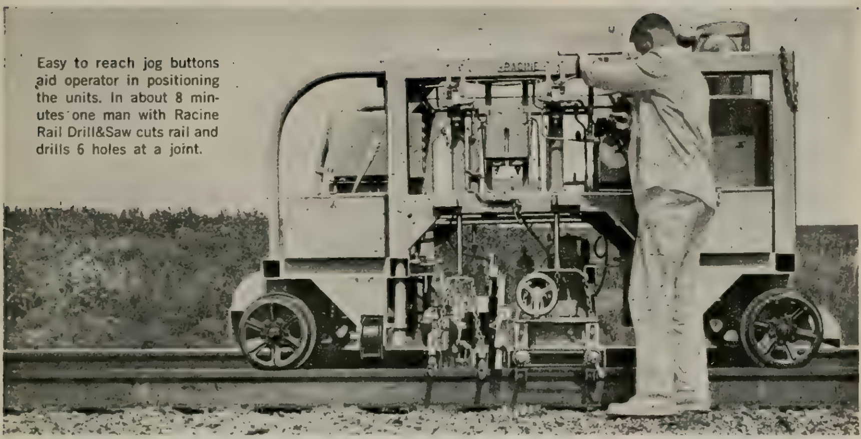
TEXACO

Petroleum Products and Systematic Engineering Service

TEXACO

TEXACO INC.
RAILWAY SALES DIVISION
135 East 42nd St., New York 17, N. Y.

NEW YORK • CHICAGO • SAN FRANCISCO • ST. LOUIS • ST. PAUL • ATLANTA



Easy to reach jog buttons aid operator in positioning the units. In about 8 minutes one man with Racine Rail Drill&Saw cuts rail and drills 6 holes at a joint.

UP TO 21 INSULATED JOINTS PER DAY

The Racine Rail Drill&Saw, equipped with a multiple 3 spindle drill and hydraulic feed reciprocating saw, is a dual-purpose, single operator machine for cutting-in insulated joints or cropping rail in track.

Up to 21 insulated joints per day in ribbon rail have been completed by a single machine, using the following sequence of operations:

(1) Saw rail and drill 6 holes.
(2) Expand joint with Templeton-Kenley Hydraulic Expander.
(3) Insert end post.
(4) Assemble angle bars (using electric impact wrench).

The 3 spindle drill unit may be pre-set to bore two or three holes on 5½″ to 7″ centers. Hole center adjustment is made by inserting solid spacer blocks, forming a "fixed" center drill head.

The saw unit is a new concept for reciprocating rail saws. Accurately controlled hydraulic feed pressure is used to cut rail consistently fast and straight. Blade cost is only a few cents per cut.

The machine is basically a self-propelled carriage and power plant for mounted saw and drill units. It is also available in various combinations of saw and drill units to suit your needs for in-track rail cropping operations. Electrical outlets on the machine give you plug-in power for impact wrench, drill bit grinder, work lights or other portable tools.

Write for more information today: Racine Hydraulics & Machinery, Inc., **Dept. B95, Racine, Wisconsin.** RR-150

RACINE

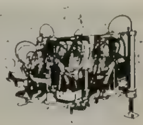
Unit Tamper

Portable Rail Drill

Portable Rail Saw

Anchor Applicator

Rail Drill&Saw



Production and Spot Tampers

Hubbard Super Service Alloy Spring Washers
Hubbard Super Steel Alloy Spring Washers
Hubbard Track Tools

Hubbard Tool Division
UNIT RAIL ANCHOR CORPORATION
New York Pittsburgh Chicago

Unit Rail Anchor

UNIT RAIL ANCHOR DIVISION
UNIT RAIL ANCHOR CORPORATION
NEW YORK PITTSBURGH CHICAGO

Area Code 305
P. O. Box 10378 LOgan 6–7922

GREENHEART, INC.
1431 N. E. 26th Street
FORT LAUDERDALE, FLORIDA

President—John L. McEwen—Quarter Century Experience

IMPORTERS:
GREENHEART—3300F Piles, Lumber, Timbers Long Length
MORA EXCELSA—Lumber and Timbers
MANBARKLAK—Piles
ANGELIQUE (Basra Locus)—Piles, Lumber and Timbers
and other Woods from
Burma, Siam, Australia, Africa and South America
Data furnished on request

E-x-t-e-n-d T-i-e L-i-f-e!

Hold Gage!

USE TIE PLATE *LOCK SPIKES*

One-piece Design

LOCK SPIKES hold tie plates firmly in place on cross-ties and bridge timbers.

LOCK SPIKES are quickly and easily driven, or removed, *with standard track tools.*

Driven to refusal, the spread shank is compressed by the walls of the hole. Tie plates are held against horizontal and vertical movement under spring pressure. Play between the spike and the hole is eliminated—abrasion and seating of tie plates is overcome.

LOCK SPIKES hold their position in the tie, and redriving to tighten the plate is not required. They provide a quiet and strengthened track.

Annual cost of ties and maintenance expense is reduced by extending the life of ties and holding gage. Here is one answer to conservation of materials and labor. Write for free folder.

BERNUTH, LEMBCKE CO., INC.

420 Lexington Avenue, New York 17, N. Y.

Actual Size

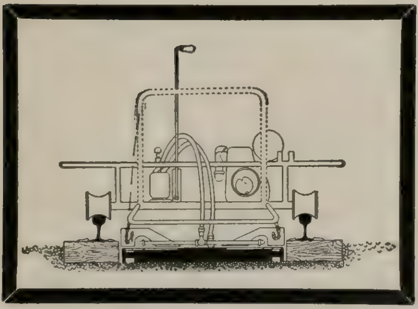
THE DOUBLE U RAIL ANCHOR

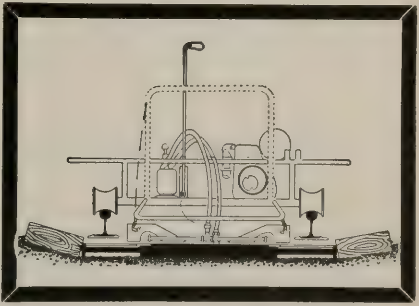
ACHUFF RAILWAY SUPPLY CO.
ST. LOUIS, MO.

Model N U Tie Cutter

HERE IS THE WINNING TEAM

The Woolery NU Tie Cutter and the Woolery Tie-end Remover preserve the line and surface of the track and at the same time reduce the cost of tie renewals. Ties can be removed without trenching, jacking up track or adzing tops of rail-cut ties. With this team you simply cut both ends of tie, pry out center piece, insert in its place the tie-end remover and out go the tie ends pushed by the double acting, double ended hydraulic cylinder of the Tie-end remover.





FOR HIGHEST EFFICIENCY USE TWO TIE CUTTERS WITH ONE TIE-END REMOVER

WOOLERY MACHINE COMPANY

MINNEAPOLIS, MINN.

WOODINGS-VERONA TOOL WORKS
Pioneer Manufacturers
of
HIGH GRADE TRACK TOOLS
and
SPRING WASHERS FOR TRACK
Since 1873
VERONA, PA. CHICAGO, ILL.

WOODINGS FORGE & TOOL COMPANY
Makers
of
WOODINGS RAIL ANCHORS
VERONA, PA. CHICAGO, ILL.

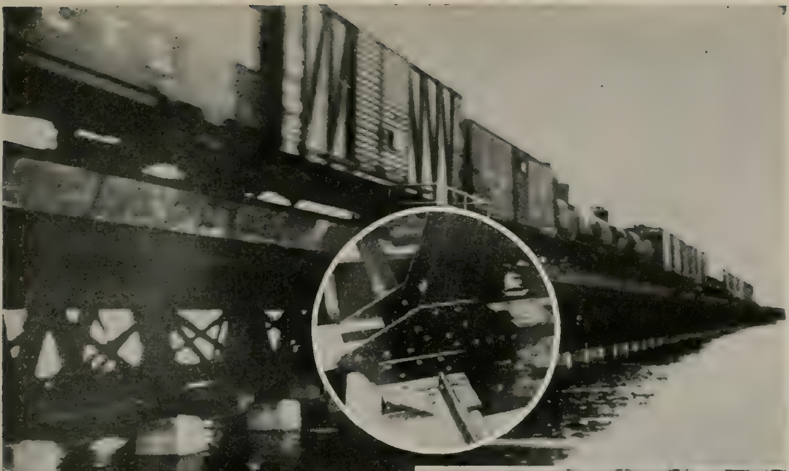
Notes on
Railroad Location and Construction Procedures
from the School of Experience

By J. A. Given

A series of notes, comments, short-cut methods and "tricks of the trade" written by a railroad location engineer of many years of practical experience for the benefit of young engineers.

Price $0.50

AMERICAN RAILWAY ENGINEERING ASSOCIATION
59 East Van Buren Street
Chicago 5, Ill.



The railroad bridge pictured has been protected satisfactorily with Brooks Protective Coating for over five years. The steel in the structure is subjected to atmospheric contamination, water action and winter snow and ice.

BROOKS

PROTECTIVE COATING FOR BRIDGES AND BUILDINGS

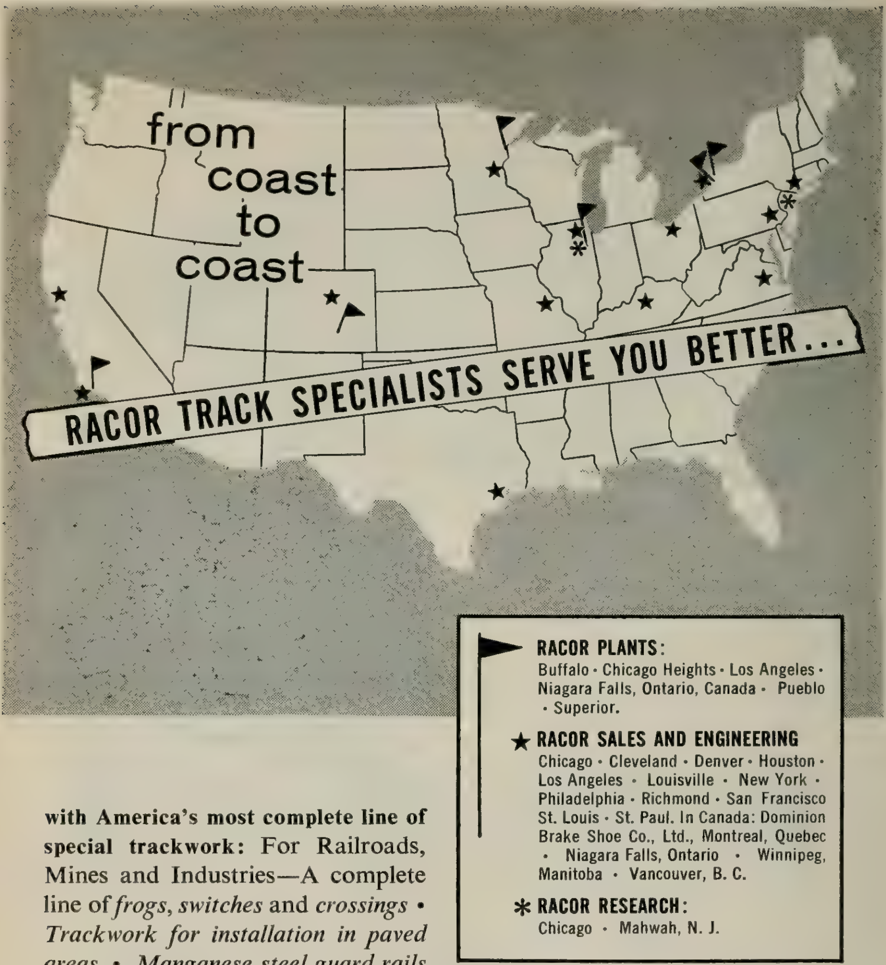
Corrugated metal buildings are subjected to corrosion and in some cases, severe corrosive conditions exist. Brooks Protective Coating will resist corrosion which causes deterioration to metal surfaces.

Easily applied by spray or brush.

Talk it over with the BROOKS OIL man near you!

The BROOKS OIL Company
Established 1876
General offices and U.S. plant: 3304 East 87th Street • Cleveland 27, Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton, Ontario

The Brooks Oil International Company: Exporters



RACOR PLANTS:
Buffalo · Chicago Heights · Los Angeles · Niagara Falls, Ontario, Canada · Pueblo · Superior.

★ **RACOR SALES AND ENGINEERING**
Chicago · Cleveland · Denver · Houston · Los Angeles · Louisville · New York · Philadelphia · Richmond · San Francisco St. Louis · St. Paul. In Canada: Dominion Brake Shoe Co., Ltd., Montreal, Quebec · Niagara Falls, Ontario · Winnipeg, Manitoba · Vancouver, B. C.

✱ **RACOR RESEARCH:**
Chicago · Mahwah, N. J.

with America's most complete line of special trackwork: For Railroads, Mines and Industries—A complete line of *frogs, switches* and *crossings* • *Trackwork for installation in paved areas* • *Manganese steel guard rails* • *Automatic switch stands* • *Samson switch points* • *Snow-Blowers* • *Switch point guards* • *Rail and flange lubricators* • *Tie pads* • *Racor studs* • *Dual spike setters* • *Dual spike drivers* • *Car retarders.*

with America's most complete trackwork manufacturing facilities: Coast to coast to serve your needs.

with America's most complete trackwork engineering service: This lies in making available to our customers Racor's engineering experience—*practical* experience from years of designing and manufacturing . . . *advanced* experience solving tomorrow's trackwork problems today in Racor research laboratories.

Why not let us help *you* with your trackwork problems?

A-1646
RACOR

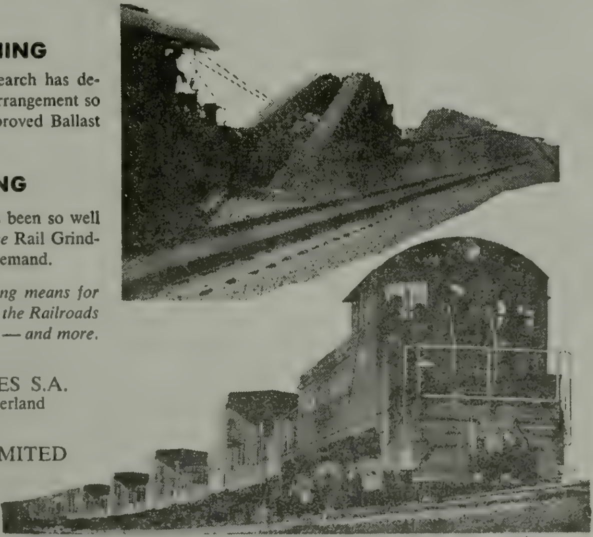
RAILROAD PRODUCTS DIVISION
530 Fifth Avenue, New York 36, New York

AMERICAN Brake Shoe COMPANY

PROGRESS
REPORT

SPENO

Here are the up-to-date facts on the SPENO Ballast Cleaning and the SPENO Rail Grinding Services.



BALLAST CLEANING

SPENO Engineering and Research has developed a superior screening arrangement so that we are now using an improved Ballast Cleaner with greater efficiency.

RAIL GRINDING

Our Rail Grinding Service has been so well received — we now have *Three* Rail Grinding Trains to take care of the demand.

SPENO is constantly developing means for better service to make sure that the Railroads receive everything they pay for — and more.

Outside North American continent:

SPEMA RAIL SERVICES S.A.
Grand-Pont 2, Lausanne, Switzerland

Canadian Sales Representatives:

THE HOLDEN CO. LIMITED
614 St. James St., West
Montreal, Canada

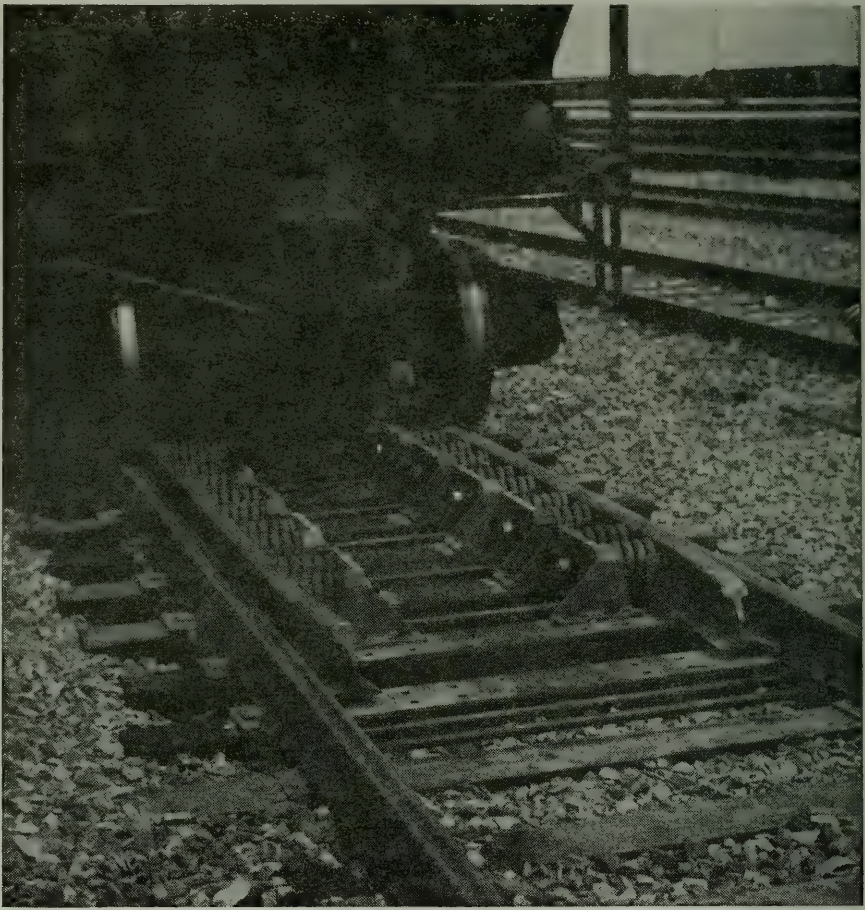
Just Ask the Railroads That have used us!

DEDICATED TO PROGRESS
P R I
MEMBER

FRANK SPENO RAILROAD BALLAST CLEANING CO., INC.

Clark Street
East Syracuse, N. Y.

306 North Cayuga St.
Ithaca, N. Y.



THE TRASCO CAR RETARDER

HUNDREDS IN SERVICE
IN CLASS YARD TRACK

TRACK SPECIALTIES COMPANY
P.O. BOX 729 WESTPORT, CONNECTICUT

American Railway Engineering Association—Bulletin

Bulletin 593
Proceedings Vol. 66*

June–July 1965

CONVENTION ISSUE

CONTENTS

Report of the 64th Annual Convention, March 23–25, 1965, McCormick Place, Chicago, including abstracts of all discussions, all formal action on Manual material, specific papers and addresses presented in connection with committee reports, and other official business of the Association 587

Tie renewals and costs per mile of maintained track 780

Memoir, John Edwin Armstrong 781

Report of Executive Secretary 785

Report of Treasurer 805

Constitution 807

Index of Proceedings, Vol. 66, 1965 819

---

* The contents of this Bulletin and the other Bulletins of the Association from Bulletin 587, September-October 1964 (except Bulletin 592, March 1965), constitute the Annual Proceedings of the Association, Vol. 66.

Copyright 1965, by American Railway Engineering Association

BOARD OF DIRECTION

1965–1966

President

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.

Vice Presidents

J. M. Trissal, Vice President, Illinois Central Railroad, Chicago, Ill. 60605
T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va. 23213

Past Presidents

L. A. Loggins, Chief Engineer, Southern Pacific Company, Texas and Louisiana Lines, Houston, Tex. 77001
T. F. Burris, Retired General Manager, Construction and Maintenance of Way, Chesapeake & Ohio Railway—Baltimore & Ohio Railroad, Huntington, W. Va.

Directors

A. L. Sams, Chief Engineer, Illinois Central Railroad, Chicago, Ill. 60605
D. C. Hastings, Vice President—Operations, Atlantic Coast Line Railroad, Jacksonville, Fla. 32202
B. B. Lewis, Professor of Railway Engineering, Purdue University, Lafayette, Ind.
H. M. Williamson, Chief Engineer System, Southern Pacific Company, San Francisco, Calif. 94105
H.E. Wilson, Assistant Chief Engineer—System, Atchison, Topeka & Santa Fe Railway, Chicago, Ill. 60604
J. S. Parsons, Engineering Consultant, Erie Lackawanna Railroad, Cleveland, Ohio 44115
S. H. Poore, Office Engineer, Chesapeake & Ohio Railway, Huntington, W. Va. 25718
F. N. Beighley, Roadway Engineer, St. Louis–San Francisco Railway, Springfield, Mo. 65801
D. H. Shoemaker, Chief Engineer, Northern Pacific Railway, St. Paul, Minn. 55101
M. S. Reid, Assistant Chief Engineer—Maintenance, Chicago & North & Western Railway, Chicago, Ill. 60606
J. B. Clark, Chief Engineer, Louisville & Nashville Railroad, Louisville, Ky. 40201
J A. Rust, Chief Engineer, Southern Railway System, Atlanta, Ga. 30303

Treasurer

A. B. Hillman, Retired Chief Engineer, Belt Railway of Chicago; Chicago & Western Indiana Railroad, Chicago

Executive Secretary

Earl W. Hodgkins, 59 East Van Buren Street, Chicago, Ill. 60605

Assistant Secretary

E. G. Gehrke, 59 East Van Buren Street, Chicago, Ill. 60605

**Published by the American Railway Engineering Association, Monthly, January, February, March, November and December; Bi-Monthly, June-July, and September-October, at 2211 Fordem Avenue, Madison, Wis. 53701. Editorial and Executive Offices,
59 East Van Buren Street, Chicago, Ill. 60605
Second class postage paid at Madison, Wis.
Accepted for mailing at special rate of postage for in Section 1103, Act of October 3, 1917, authorized on June 29, 1918.
Subscription $10 per annum.**

PROCEEDINGS

OF THE

SIXTY-FOURTH ANNUAL CONVENTION

OF THE

American Railway Engineering Association

Engineering Division, Association of American Railroads

HELD AT

McCORMICK PLACE, CHICAGO
March 23–25, 1965

VOLUME 66

OFFICERS, 1964-1965

T. F. Burris
President
Special Engr., C.&O. Ry.

A. V. Johnston
Sr. Vice President
Chief Engr.
Can. Natl. Rys.

J. M. Trissal
Jr. Vice President
Vice Pres.
Ill. Cent. RR.

C. J. Code
Past President
Asst. Chief Engr.-Staff
Penn. RR.

L. A. Loggins
Past President
Chief Engr.
S.P. Co., Tex. & La. Lines

A. B. Hillman
Treasurer
Ret. Chief Engr.
C.&W.I. RR.

Earl W. Hodgkins
Executive Secretary

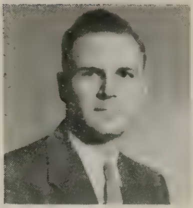
DIRECTORS, 1964-1965

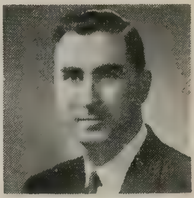
W. L. Young
1962–65
Res. Vice Pres.
N.&W. Ry.

T. B. Hutcheson
1962–65
Chief Engr.
S.A.L. RR.

C. E. Defendorf
1962–65
Chief Engr.
N.Y.C. Sys.

John Ayer, Jr.
1962–65
Vice Pres.—Oper.
D.&R.G.W. RR.


A. L. Sams
1963–66
Chief Engr.
Ill. Cent. RR.


D. C. Hastings
1963–66
Asst. Vice Pres.—Oper.
A.C.L. RR.

B. B. Lewis
1963–66
Prof. Ry. Engr.
Purdue Univ.

H. M. Williamson
1963–66
Chief Engr. Sys.
So. Pac. Co.

H. E. Wilson
1964–67
Asst. Chief Engr. Sys.
A.T.&S.F. Ry.

J. S. Parsons
1964–67
Engrg. Cons.
E.L. RR.

S. H. Poore
1964–67
Office Engr.
C.&O. Ry.

F. N. Beighley
1964–67
Rdway. Engr.
St. L.-S.F. Ry.

NUMERICAL INDEX TO COMMITTEE REPORTS

	Report	Discussion
1—Roadway and Ballast	Bul. 591, p. 521	Bul. 593, p. 745
3—Ties and Wood Preservation	Bul. 589, p. 225	Bul. 593, p. 607
4—Rail	Bul. 591, p. 445	Bul. 593, p. 756
5—Track	Bul. 591, p. 495	Bul. 593, p. 761
6—Buildings	Bul. 589, p. 187	Bul. 593, p. 719
7—Wood Bridges and Trestles	Bul. 590, p. 299	Bul. 593, p. 674
8—Masonry	Bul. 590, p. 305	Bul. 593, p. 661
9—Highways	Bul. 588, p. 89	Bul. 593, p. 635
11—Engineering and Valuation Records	Bul. 589, p. 231	Bul. 593, p. 604
13—Water, Oil and Sanitation Services	Bul. 588, p. 99	Bul. 593, p. 631
14—Yards and Terminals	Bul. 588, p. 127	Bul. 593, p. 618
15—Iron and Steel Structures	Bul. 590, p. 291	Bul. 593, p. 653
16—Economics of Railway Location and Operation	Bul. 588, p. 143	Bul. 593, p. 710
18—Electricity	Bul. 590, p. 339	Bul. 593, p. 647
20—Contract Forms	Bul. 588, p. 153	Bul. 593, p. 645
22—Economics of Railway Labor	Bul. 589, p. 257	Bul. 593, p. 613
24—Cooperative Relations with Universities	Bul. 590, p. 325	Bul. 593, p. 693
25—Waterways and Harbors	Bul. 588, p. 167	Bul. 593, p. 615
27—Maintenance of Way Work Equipment	Bul. 589, p. 273	Bul. 593, p. 742
28—Clearances	Bul. 589, p. 245	Bul. 593, p. 611
30—Impact and Bridges Stresses	Bul. 588, p. 183	Bul. 593, p. 671
31—Continuous Welded Rail	Bul. 591, p. 507	Bul. 593, p. 757

PROGRAM

Sixty-Fourth Annual Meeting

March 23–25, 1965

Tuesday, March 23

Morning Session—Banquet Room—9:30 to 12:00

Invocation Dr. Kenneth Hildebrand, the Central Church of Chicago.

Recognition of speaker's table guests.

Presidential Address—T. F. Burris, Special Engineer, Chesapeake & Ohio Railway.

Report of Executive Secretary—Earl W. Hodgkins

Report of Treasurer—A. B. Hillman, Retired Chief Engineer, Chicago & Western Indiana Railroad and Belt Railway of Chicago.

Greetings from the National Railway Appliances Association—W. A. Enstrom, (President).

Keynote Address—Where Do We Go From Here?—by R. R. Manion, Vice President, Operations and Maintenance Department, AAR.

Reports of Committees	Bulletin Numbers
11—Engineering and Valuation Records (10:45)	589
3—Ties and Wood Preservation (11:00)	589
28—Clearances (11:15)	589
22—Economics of Railway Labor (11:30)	589
25—Waterways and Harbors (11:45)	588

Afternoon Session—Banquet Room—1:30 to 5:00

14—Yards and Terminals (1:30)	588
Address—Engineering Efficient Transfer Terminals, The Keystones of Successful Rail–Highway Transportation (Illustrated), by R. S. Reebie, Assistant Vice President—Marketing Planning and Research, New York Central System.	
13—Water, Oil and Sanitation Services (2:30)	588
9—Highways (2:55)	588
Address—ICC Report on Prevention of Grade-Crossing Collisions, by J. W. Hayes, General Counsel, Association of Western Railways.	
20—Contract Forms (3:35)	588
18—Electricity (3:55)	590
Address and Demonstration—Lighting is Not a Luxury (Illustrated), by R. L. Henderson and B. R. Boyland, Lamp Division, General Electric Company.	

Wednesday, March 24

Morning Session—Lakeside Room—9:00 to 12:00

Reports of Committees	Bulletin Numbers
15—Iron and Steel Structures (9:00)	590
Address—Welded Railroad Bridges (Illustrated), by J. E. South, Chief Engineer—Structures, Pennsylvania Railroad.	
8—Masonry (9:40)	590
Address—Giant Moon-Port Structures Take Shape at Cape Kennedy (A member of AREA describes work in moon program) (Illustrated), by Anton Tedesko, Vice President, Roberts & Schaefer Company.	
30—Impact and Bridge Stresses (10:20)	588
7—Wood Bridges and Trestles (10:45)	590
Address—Performance and Durability of Glued Laminated Railway Bridges (Illustrated), by F. P. Drew, Research Engineer Structures, AAR.	
24—Cooperative Relations With Universities (11:15)	590
Address—What Price Glamor, by Professor W. L. Everitt, Dean of Engineering, University of Illinois.	

Association Luncheon—Banquet Room, 12:00 Noon

Presentation of those at speaker's table.

Presentation of those at chairmen's table.

Announcement of results of election of officers.

Address—The Challenge of Change for the Railroads, by G. S. DeVine, President, Chesapeake & Ohio Railway.

Afternoon Session—Lakeside Room—2.00 to 4.00

16—Economics of Railway Location and Operation (2:00)	588
Address—New Developments in Engineering Use of Computers, by Professor C. L. Miller, Head, Department of Civil Engineering, Massachusetts Institute of Technology.	
Demonstration—Will Illustrate Time-Sharing Principle of Computer Utilization by Actually Introducing Railway Engineering Problems Into a Computer Located at MIT in Cambridge, Mass., Through a Console Located in McCormick Place, With the Solution Being Printed Out at Chicago a Few Seconds Later.	
6—Buildings (2:40)	589
Address and Demonstration—Critical Path Method for the Railroad Industry (Illustrated), by F. J. Raskopf, Jr., Associate Systems Engineer, International Business Machines Corporation.	
27—Maintenance of Way Work Equipment (3:40)	589

Thursday, March 25

Morning Session—South Half of Banquet Room—9:00 to 12:00

Reports of Committees	Bulletin Numbers
1—Roadway and Ballast (9:00)	591
Address—1964 Earthquake Damage to Alaska Railroad (Illustrated), by I. P. Cook, Chief Engineer, Alaska Railroad.	
4—Rail (9:45)	591
31—Continuous Welded Rail (10:05)	591
5—Track (10:20)	591
Panel Discussion—Standardization: Its Progress, Its Pitfalls, Who is Using, and of Those Members Not Using—Why Not? Panel members: J. M. Salmon, Jr., Chief Engineer, Clinchfield Railroad (Moderator); C. J. Code, Assistant Chief Engineer—Staff, Pennsylvania Railroad; F. R. Woolford, Chief Engineer, Western Pacific Railroad; H. M. Williamson, Chief Engineer—System, Southern Pacific Company; K. H. von Kampen, Chief Engineer, Railroad Division, Pettibone Mulliken Corporation.	

Closing Business Session (11:20)
Installation of Officers
Adjournment (12:00 noon)

Nominating Committee—1965 Election

Past Presdents

F. R. Woolford, *Chairman*
Chief Engineer, W. P. RR.
E. J. Brown
Chief Engr., Burl. Lines
R. H. Beeder
Chief Engr. Sys., A.T. & S. F. Ry.
C. J. Code
Asst. Chief Engr.—Staff, P.R.R.
L. A. Loggins
Chief Engr., S. P. Co., Tex. & La. Lines

Elected Members

C. Neufeld
Engr. of Bridges, C.P.R.
R. L. Mays
Chief Engr., N. Y. C. & St. L. RR.
T. D. Wofford, Jr.
Asst. to Chief Engr., I. C. RR.
C. G. Davis
Chief Engr., K. C. S. Ry.
D. V. Messman
Asst. to Chief Engr., Sou. Ry.

The foregoing committee, the consist of which includes the five latest living past presidents of the Association and five elected members of the Association who are not past presidents, formulated their official slate of nominations at a meeting in Chicago on September 15, 1964, which nominations were presented to letter ballot vote of the membership with the January–February 1965 issue of the *AREA News*.

Successful Candidates in 1965 Election of Officers and Members of Nominating Committee

For President

A. V. Johnston, Chief Engineer, Canadian National Railways, Montreal, Que.

*For Senior Vice President**

J. M. Trissal, Vice President, Illinois Central Railroad, Chicago, Ill.

For Junior Vice President

T. B. Hutcheson, Chief Engineer, Seaboard Air Line Railroad, Richmond, Va.

For Directors

D. H. Shoemaker, Chief Engineer, Northern Pacific Railway, St. Paul, Minn.

M. S. Reid, Assistant Chief Engineer—Maintenance, Chicago & North Western Railway, Chicago, Ill.

J. B. Clark, Chief Engineer, Louisville & Nashville Railroad, Louisville, Ky.

J. A. Rust, Chief Engineer, Southern Railway System, Atlanta, Ga.

For Members of Nominating Committee

R. W. Mauer, Special Engineer, Atchison, Topeka & Santa Fe Railway, Chicago, Ill.

G. V. Guerin, Chief Engineer, Great Northern Railway, St. Paul, Minn.

C. Baker, Chief Engineer, Missouri Pacific Railroad; Texas & Pacific Railway, St. Louis, Mo.

H. W. Kellogg, Assistant Chief Engineer Maintenance of Way, Chesapeake & Ohio Railway, Huntington, W. Va.

E. A. Johnson, Engineer of Bridges, Illinois Central Railroad, Chicago, Ill.

---

* Under the provisions of the Constitution, J. M. Trissal advances automatically from junior vice president to senior vice president.

Committee of Tellers—1965 Election

The following committee was appointed to canvass the ballots for officers and for members of the nominating committee, the count being made on March 24:

J. E. Wiggins, Jr., *Chairman*
J. A. Barnes
L. R. Beattie
H. R. Beckmann
J. E. Beran
L. W. Cantwell
C. E. DeGeer
R. Dejaiffe
A. H. Galbraith
E. C. Harris
W. R. Hyma
B. D. Jones, Jr.
J. L. Kampwirth
L. O. Keating
R. E. Kuston
D. J. Moody
W. J. Murdock
C. E. Peterson
F. H. Smith
T. A. Tennyson, Jr.
C. L. Waterbury
R. C. Wearing
E. R. Wiltz
R. A. Vollrath
C. E. Peterson

Proceedings

Running Report of the 64th Annual Convention of the American Railway Engineering Association and Concurrent Annual Meeting of the Engineering Division, Association of American Railroads, March 23–25, 1965, McCormick Place, Chicago, Including Abstracts of All Discussions, All Formal Action on Committee Presentations, Specific Papers and Addresses Presented in Connection with Committee Reports, and Other Official Business of the Association and Division

Opening Session, March 23, 1965

President T. F. Burris*, Presiding

[The opening session of the 64th Annual Convention convened at 9:30 am].

PRESIDENT BURRIS: Members of the American Railway Engineering Association and guests:

Welcome to the 64th Annual Convention of this Association and the Annual Meeting of the Engineering Division of the Association of American Railroads.

At the President's Dinner last night I announced that we had some 1230 or more people registered before our Convention opened but it seems that certain forces are working against us today—an ice storm making it hard to get here, and the astronauts blasting off, making everybody want to watch them on television. The astronauts got off all right, but the storm outside continues.

I had intended to have the invocation at this time, but Dr. Hildebrand has been delayed, so we shall have to proceed with our program and interrupt it later if he gets here.

To many of you, attending a convention in McCormick Place is not new, because we held a meeting here in 1961—our president at that time was E. J. Brown—and we attended the American Railway Progress Exposition here in the fall of 1963. Again this year we have an exhibit on the floor above, which I hope each of you will have an opportunity to visit. I am sure you will find it worth while.

Our headquarters are in the Palmer House, one of the finest hotels in the country, which is spending a great deal of money in improving its guest rooms. I imagine some of you have been discommoded because of this fact. The hotel people tell me that they will be finished in about another 12 months.

I am very pleased about the large registration, particularly since much of it took place before our Convention actually started. This means that you were interested in coming not only to hear about the work of our committees, but also to take advantage of the opportunity to view the splendid display on the floor above.

Vice President Johnston and I took about 2½ hours yesterday afternoon to make a walking trip around the exhibit, saying hello to old friends. I think you will have to stay there a little longer than we did, however, if you want to really benefit from the exhibits.

We are pleased to have with us the ladies whom I see in the audience; you always add to our Convention. I think you gentlemen will agree with me that we wouldn't have gotten quite as far as we have if we hadn't had the aid and assistance of our good wives.

---

* Special Engineer, Chesapeake & Ohio Railway.

I should like now to introduce those sitting at the speaker's table, your officers and directors, special guests, and many of our past presidents. As I call your name, gentlemen, will you please stand momentarily to be recognized. It will be appreciated if those in the audience will withhold their applause until everyone has been introduced.

First, I should like to introduce the past presidents, and I shall start with the most recent one, L. A. Loggins, president 1963–1964, chief engineer, Southern Pacific Company, Texas & Louisiana Lines, Houston, Tex.

Next is C. J. Code, president 1962–1963, assistant chief engineer, Pennsylvania Railroad, Philadelphia, Pa.

Then, R. H. Beeder, president 1961–1962, chief engineer, system, Atchison, Topeka & Santa Fe Railway, Chicago.

E. J. Brown, president 1960–1961, Chief Engineer, Burlington Lines, Chicago.

F. R. Woolford, president 1959–1960, chief engineer, Western Pacific Railroad, San Francisco, Calif.

Wm. J. Hedley, president 1956–1957, assistant vice president, Norfolk & Western Railway, St. Louis, Mo. He is also the Mayor of Clayton, Mo.

George M. O'Rourke, president 1955–1956, retired assistant engineer maintenance of way, Illinois Central Railroad. When he isn't in Ireland he makes his home in Chicago.

Next was to have been Tom Blair, president 1951–1952, retired chief engineer of the Santa Fe, but he hasn't arrived yet, probably because of the weather.

C. H. Mottier, president 1948–1949, retired vice president, Illinois Central Railroad, Clearwater, Fla.

I should now like to introduce the two men seated at my extreme right—Walter S. Lacher, secretary emeritus, who served the AREA from 1938 to 1950; I guess he also was delayed by the storm; and Neal D. Howard, executive secretary emeritus, who succeeded Mr. Lacher and has served your Association for 14 years, retiring last July. You all know Neal and know how efficiently and well he conducted the duties of his office.

Next is our treasurer, A. B. Hillman, retired chief engineer of the Chicago & Western Indiana Railroad and the Belt Railway, Chicago.

Next is Earl W. Hodgkins, our new executive secretary.

The first two gentlemen on my left are your senior vice president, A. V. Johnston, chief engineer, Canadian National Railways, and your junior vice president, J. M. Trissal, vice president, Illinois Central Railroad.

I shall skip the next two men momentarily and shall now introduce the members of the Board of Direction.

W. L. Young, resident vice president, Norfolk & Western Railway, Norfolk, Va.

T. B. Hutcheson, chief engineer, Seaboard Air Line Railroad, Richmond, Va.

C. E. Defendorf, chief engineer, New York Central System, New York.

John Ayer, Jr., vice president—operations, Denver & Rio Grande Western Railroad, Denver, Colo.

One of our Board members was unavoidably detained. He is A. L. Sams, chief engineer, Illinois Central Railroad, Chicago.

D. C. Hastings, assistant vice president—operations, Atlantic Coast Line Railroad, Jacksonville, Fla.

B. B. Lewis, professor of railway engineering, Purdue University, Lafayette, Ind.

H. M. Williamson, chief engineer—system, Southern Pacific Company, San Francisco, Calif.

H. E. Wilson, assistant chief engineer—system, Atchison, Topeka & Santa Fe Railway, Chicago.

J. S. Parsons, engineering consultant, Erie Lackawanna Railroad, Cleveland, Ohio.

S. H. Poore, office engineer, Chesapeake & Ohio Railway, Huntington, W. Va.

F. N.. Beighley, roadway engineer, St. Louis–San Francisco Railway, Springfield, Mo.

Now you may applaud [Applause]

Of course you recognized the fact that I skipped two men at the table. I did this purposely, because you are going to hear from them a little later and I shall introduce them at that time.

The first official item of business on our program is the approval of the minutes of the 1964 Annual Convention, which were published in the June–July 1964 Convention issue of the AREA Bulletin, No. 586, a copy of which was sent to each of you. Unless I hear an objection or corrections to these minutes, I shall dispense with the reading of their some 300 pages and will entertain a motion that the minutes be approved as printed.

[A motion to approve the 1964 minutes as published was made, was duly seconded, was put to a vote and carried.]

Address of President T. F. Burris

Members of the American Railway Engineering Association and guests.

Welcome to this, our 64th Annual Convention, which culminates another year of earnest effort on the part of every member and committee to promote the ideals of our Association.

We are again meeting in McCormick Place and enjoying its wonderful facilities. We are fortunate, too, in having in conjunction with our meeting a very fine exhibition put on by the National Railway Appliance Association, housed under this same roof. I am sure NRAA has gone all out to make this one of its best exhibits, and I hope everyone present will take advantage of it and find something there that will be of benefit to him and to his work.

My year as your president has been a pleasant, rewarding and most inspiring time for me. I have been especially interested in the work of our committees and have attended and participated in at least one meeting of 20 different committees. I have been pleased and gratified at their growing profesionalism and the thoroughness of their studies. Our committees are a vital part of our organization, and it is hoped that they will continue to pursue studies which will aid and stimulate every person in this Association. I would like to see everyone a member of a committee and participating in its work. As a result of my visits to the committees, I have reached certain conclusions, which I should like to make as recommendations for the future.

I am concerned about the time some committees take to reach a conclusion as to what to recommend. Some committees belabor a subject to the extent that often when the report is finally made the subject reported on has been out moded or is out of date. However, this does not mean that we must lessen the thoroughness of our studies.

Greater use should be made of our younger engineers in committee work. They have the benefit of newer ideas and theories in engineering education and have much to contribute to a progressive organization. At the same time they have much to learn from experienced engineers. The vitality and strength of the AREA are dependent upon its ability to attract and assist in the professional development of the young engineer.

As your representative I have visited railway engineering offices in two foreign countries and have participated in discussions of problems common to us all. I am now corresponding with the European counterpart of AREA with the hope that we may have a greater exchange of ideas, methods and materials.

Our National government is becoming increasingly concerned with the nation's need for improved transportation. Industry is demanding the use of larger cars, greater wheel loads and faster train speeds. To satisfy these demands will require outstanding engineering. More and greater research will be expected. Above all there must be greater cooperation between all groups dealing with the problems. To aid in accomplishing these objectives, increased demands should be made of the AAR research staff located here in Chicago and which works under the direction of W. M. Keller, vice president and G. M. Magee, director of engineering research. But the economic climate of the last few years has caused curtailment of research by AAR and AREA as carried on by this group. If they are going to meet increased demands there must be an increase in the operating budget granted the Research Center.

We must not rely solely on our Research Center to solve all our problems, nor can we always rely on tried and true methods of the past. We are going to have to come up with ideas, materials, methods and machines that are vastly different because railroads of the future are going to be vastly different. We need creative engineers.

Many times lately I have heard engineers express the thought that in the future the need for engineers will be lessened by the use of computers and other electronic devices. It is my belief we should be thinking of more ways to use electronic and data processing methods as tools of our profession. They will allow us to do a more thorough job in a shorter time.

At this time I would like to express my grateful thanks to the hard-working, conscientious Committee on Convention Arrangements, under the capable direction of Chairman E. M. Hastings, Jr. [wire crossing engineer—system, Chesapeake & Ohio].

You are all aware, I know, that our very efficient executive secretary, Neal Howard, retired during this past year. I know you will join me in sincere thanks to Mr. and Mrs. Howard for a job well done and best wishes for a happy retirement.

The void left by Mr. Howard's retirement is being ably filled by Earl Hodgkins who has assumed the responsibilities of the secretary's office. My thanks to Mr. Hodgkins and to Mrs. Hodgkins for their untiring efforts to make this meeting a success.

One of the things which has made my year as president a happy experience is the splendid loyalty and cooperation of our fine Board of Direction.

Last, but certainly not least, we appreciate the presence and assistance of the ladies in making our Convention a success.

In closing, I want to express my thanks to this great Association for the honor of serving as its president.

President Burris [continuing]: Continuing with our meeting, I would now like to introduce Mr. Hodgkins, who will give us his secretary's report as the next official matter of business.

Report of Executive Secretary

Mr. President, members of the American Railway Engineering Association, guests and ladies:

The report of your Executive Secretary before this Convention is only a summary of the complete report which is published in the March Year Book Bulletin. What I have to say comes to you as a "Preview of Coming Attractions" because few of you have received the Bulletin, since it was mailed only late last week. This is as it should be, I guess, because if you all had received your Bulletin what I have to say now would be "old hat."

At the outset, I want to report to you that your Association is "perking" along on all cylinders. Although 1964 was a deficit year financially, I am pleased to report that the financial condition of the AREA is sound, as Treasurer Hillman will describe in a few minutes and as is fully discussed in the March Bulletin.

The 66th year of the American Railway Engineering Association was one of change and accomplishment—change in the Association's top administrative position and in the pattern of Annual Meetings; accomplishment in successfully progressing a number of highly important projects and functions of the Association.

Without a doubt the top AREA news story of 1964 was the retirement on July 31 of Neal D. Howard as executive secretary, and the appointment of the speaker as his successor. Mr. Howard had been secretary and executive secretary for more than 14 years, serving the Association with devotion, dedication and distinction during a period of great technological and economic change on American railroads, each of which influenced the conduct of Association affairs. On November 6, the Board of Direction elected Mr. Howard to the honorary position of Executive Secretary Emeritus. I want to say that this report is partly his report. Although I am delivering it, the things that were accomplished in 1964 and currently were initiated by him to a large extent, and their fulfillment is a tribute to his organizational work.

Another change that should be noted for the record relates to the AREA's dual capacity as the Engineering Division, Association of American Railroads. Since 1918, when the dual capacity was inaugurated, the AREA has, in addition to its existence as an independent Association, consisting of individuals, served as an integral part of the Operations and Maintenance Department, AAR. It functioned first as the Construction and Maintenance Section of the Engineering Division and since January 1, 1961, has functioned as the whole Engineering Division.

As such, it has operated under Curtis D. Buford, vice president of the Operations and Maintenance Department, since 1959. On August 31, 1964, Mr. Buford resigned to become president of the Pittsburgh & Lake Erie Railroad and was succeeded by Rex R. Manion, formerly vice president of the New York Central System and a former director of the AREA.

1964 Convention

Another highly significant change during 1964 was the return to the AREA's normal 2½-day Annual Conventions, after 2 years of restricted-length Conventions. This affair was held on March 9–11 at the Pick-Congress Hotel, Chicago, and was attended by more than 1000 members and guests.

Accomplishments During 1964

In retrospect, the Association can claim dramatic accomplishments in a number of diverse areas during the year just ended.

One of these is the historic action by the Board of Direction, at a meeting on November 6, in giving its approval to the principle of holding regional meetings in various parts of the century remote from Chicago. However, not more than one regional meeting will be permitted in any one year.

The purpose of regional meetings is to stimulate interest in the AREA on the part of members who seldom if ever have the opportunity of attending an Annual Convention. This could be accomplished by participation in a meeting in their general geographical area. In addition, it is hoped that regional meetings will attract non-members who by their attendance will become aware of the high caliber of AREA members and activities, thus stimulating them to become members and take an active part in Association affairs.

It should be *emphatically* pointed out that regional meetings will not take the place of the Annual Meeting at Chicago or meetings of the Association's technical committees. No Association business will be transacted at them. In fact, attendance at any regional meeting will be drawn only from railroads in or serving the particular region.

The Board also voted to hold a pilot regional meeting in 1965, probably in October, in the West Coast–Pacific Northwest area at Portland, Ore. H. M. Williamson, an AREA director and chief engineer system, Southern Pacific, was appointed chairman of the pilot meeting.

Another accomplishment during 1964 was the action by the Board, also on November 6, to grant permanent status to the Special Committee on Continuous Welded Rail. It is now known as Committee 31—Continuous Welded Rail.

Four accomplishments relate to the work of Committee 24—Cooperative Relations with Universities, to enhance the profession of railway engineering and maintenance in the eyes of industry, the public and especially in the eyes of engineering students on college campuses. One of these accomplishments was brought to a successful conclusion, two others gained impetus, and a fourth helped bridge the gap between engineering students and railroads.

Late in September the Third Edition of the Association's Engineer Recruiting Brochure, entitled "The Railroad Industry—A Challenge and Opportunity for Engineering Graduates," came off the presses. More than 21,000 copies were printed, most of them destined to be furnished to colleges and universities in the United States and Canada during the next 4 or 5 years for free distribution to interested engineering students. Already approximately 4,000 have been distributed. In addition, more than 5,000 were purchased by railroads for use in their training programs.

The 1964 popularity of another major project of Committee 24, the Pictorial Railroad Exhibit, has been unparalleled in its three-year history. This is an exhibit of 43 photographs, properly moundted for wall or easel mounting, that depicts various phases of railroading—operations, bridges, buildings, track and several others. Starting in March when it was displayed at an Engineering Open House Exposition at the University of Illinois, the Exhibit has not remained in the secretary's office very long. It spent ths summer in Portland, Ore., where it was part of a Transportation Club Exhibit at the Oregon Museum of Science and Industry. Last fall it was used by Michigan Technological University at a Transportation Conference. Subsequent to these engagements, the Exhibit has been or will be displayed at the Ecole Polytechnique in Montreal, Que., University of California at Los Angeles, Cornell University, Newark College of Engineering, Pennsylvania State University and Iowa State University. Unfortunately, the requests of six other institutions desiring the Exhibit had to be denied because these prior commitments completely filled up the schedule for the spring semester.

Still another project of this committee that aids the image of the Association and keeps the railroad industry before engineering students is its program of arranging for speakers from railroad engineering and maintenance of way departments to address engineering groups—civil, transportation and industrial.

The project to bring engineering students to the railroads for summer employment in 1964 was sponsored by Committee 24, as it has been for a number of years.

Membership

An area that needs immediate attention by all members is membership. Actually this is a function in which members can never relax if they want a healthy, progressive Association. However, it becomes particularly important when the previous year showed a 2 percent drop in membership, as did 1964 when compared with 1963. Although this is not serious at the present time, primarily because the comparison is being made with a year in which a concentrated membership effort was made, each member should accept the challenge to bring in new members to reverse the direction of movement before it becomes a trend. This should not be too difficult because the Association has so much to offer its members, particularly the younger railway engineers and supervisors.

Why should membership show a drop except in years a concentrated membership effort is made? It can't be the membership dues, they are minimum—$15 for members and only $5 for junior members. Is it because eligible men are not made aware of the worth and advantages of AREA membership and after joining are not encouraged to become active on a committee and maintain their good standing by paying dues annually? Or, do those who drop out feel they aren't getting their money's worth? In 1964 alone, 159 members either resigned from the AREA or were dropped for non-payment of dues. Why? Certainly not all of them left the industry—this is usually a small percentage. These are questions only the individual members can answer, particularly the chief engineering and maintenance officers on the railroads.

The questions are posed seriously. The answers and the solutions of the problems determined therefrom are vital if the Association is to maintain a healthy condition and continue to progress in its efforts to serve the railroad industry.

Activities of Committees

Membership on AREA standing technical committees continues to increase, and this is good, providing the new members take an active interest in the work of their committees and contribute some of their valuable time and experience at committee meetings and through correspondence. This is where the worth of committee activity is to be found.

In the 1963 Association year, 1118 members occupied 1202 places on the technical committees; in 1964, 1151 members occupied 1244 places; and in 1965, 1187 members have been assigned to 1266 places on the 22 standing technical committees. Not all of these members have made positive contributions to the work of their committees. I hope our analysis of the 1965 Committee Activity Record shows a marked improvement. The chairmen, vice chairmen and subcommittee chairmen of the committees should accept this problem as a challenge to their leadership abilities.

Research Work

As the 1964 research budget for the AAR Engineering Division was almost $20,000 above the 1963 allotment, so the 1965 research budget of $306,100 is exactly $20,000 above the 1964 figure. Although the trend is in the right direction, each of these figures is a far cry from the $570,000 budget for 1958.

Once again work on many AAR–AREA committee-sponsored projects now under way will continue to be curtailed and the undertaking of a number of new projects will be further delayed. Why? Because the appropriation for 1965 is 35 per cent, or $167,200, below the budget approved by the General Committee of the Engineering Division (Board of Direction, AREA). In addition, the total appropriation is $47,000 below the total amount requested to adequately progress the "A" priority projects.

Summary

I would summarize 1964 in these words:

Accomplishmentwise, 1964 was an excellent year and will be hard to surpass. But, 1965 promises to exceed last year, not only from the point of view of committee work and relations with colleges and universities and their engineering students but by showing an increase in membership and a balanced budget.

However, this prophecy will come true only through the dedication and earnest effort of not only the officers and directors, but the entire membership as well. Each member may be assured that the hardest working of all will be the secretary and his staff and that they will leave no stone unturned to assure the continued forward progress and stability of the AREA in all areas of endeavor.

Given the support and cooperation of all members, the American Railway Engineering Association can retain its place of eminence in the railroad industry and in the future even surpass its attainments of the past and present to make a greater contribution to railroading the world over.

Before relinquishing the microphone I should like to express my appreciation to a number of especially worthy individuals for the help and guidance extended to me since I assumed this position last August—only about 8 months ago;

President Burris for his patience and trust; Vice President Trissal for his nearness and willingness to counsel with me; Neal Howard for his assistance, guidance and counsel during the first 3 or 4 months and for the excellent notes and memos he so considerately compiled to assist the new secretary in catching up on the status of various projects and correspondence; and to Walter Lacher for his help and words of encouragement.

Furthermore, I want to report on the loyalty, dedication and devotedness of two men who have served the Association for many years. Although they work largely in the background, I assure you that the Association bears their imprint. I am speaking, of course, and I ask that they stand and be recognized as I introduce them, of Ed Gehrke, the assistant secretary, AREA, and secretary, Engineering Division, AAR, and Norris Engman, assistant to the secretary, AREA. Ed is a veritable walking encyclopedia of Association affairs, since he has served it for 44 years; he supervises the joint AREA–AAR office force, handles the financial affairs of the Association, closely assists the secretary in making arrangements for the Annual Conventions, works closely with the General Convention Arrangements Committee on its execution of Convention plans, and multitudinous other chores. Norris has been with the Association for 13 years and handles the vast amount of details connected with committee work—assignments, personnel and reports—and edits and prepares material for publication in the various AREA publications, along with a great many other duties.

You will find no more loyal, dedicated, and devoted servants to the cause and work of the AREA than these two men. I thank them from the bottom of my heart for the help, assistance, guidance and counsel they have unstintingly given me the past 8 months.

I would like to remind you of one other important feature of this convention, the computer demonstration that will be on today and tomorrow in Meeting Room 14 on this level, just off the east-west corridor, where you will see illustrated the time-sharing concept of computer utilization. The computer itself is located at MIT in Boston. The console through which problems are entered into the computer is located here in Meeting Room 14. There will be four demonstrations each day—today at 11:00 am, and 2:00 and 4:45 pm; tomorrow at 10:00 and 11:00 am, and at 2:45 and 4:15 pm. We hope that each of you will be able to work this demonstration into your program. There are a sufficient number so that it will not interfere with your viewing the exhibits and your attendance at the technical sessions you are particularly interested in. You will find signs giving the times and place upstairs in the exhibit hall and down here in our AREA lobby.

In this note I close my first secretary's report.

Thank you. [Applause]

PRESIDENT BURRIS: Thank you, Mr. Hodgkins. I was afraid for a moment that you were going to get so enthusiastic about all the things the office has accomplished that you might overlook the two men on your staff. We can be proud that we have an office that works as efficiently as ours does here in Chicago.

I now ask A. B. Hillman, retired chief engineer, Chicago & Western Indiana and Belt Railway of Chicago, to give the report of the treasurer.

Report of the Treasurer

Mr. President, members and guests: At our Annual Meeting last March I was rather unhappy to report to you that the year 1964 would be a deficit year, financially, for the Association, with anticipated disbursements exceeding anticipated receipts in the amount of some $6,500. While an anticipated deficit did occur, I am pleased to report, that thanks to the efforts of many, disbursements exceeded receipts to the extent of only $3,284. The reasons that the larger anticipated deficit did not occur, even with an expenditure of $3,877.95 for reprinting our Engineer Recruitment Brochure, were economies effected, especially in printing, and an anticipated increase in postal rates not materializing. Also, total receipts were some $1,200 higher than estimated for the year.

I shall not go into the individual items of receipts and disbursements for 1964, all of which appear in the financial statement printed in the March Bulletin for 1965, but I shall comment briefly on certain items of receipts and disbursements in 1964, and on the financial prospects for 1965. Membership receipts, the life-line of the Association, were $825 higher than anticipated, but some $300 under those of 1963. It is imperative that these membership receipts continue on at least this level. All other receipts items were about as anticipated.

On the expenditure side, total disbursements were $1,929 under anticipation, despite an unavoidable overdisbursement in the item of pensions. This favorable situation was due almost entirely to printshop economies affected in reprinting the Portfolio of Trackwork Plans, for which $6,500 had been budgeted, and only $4,752 expended, plus an underexpenditure of $1,000 in salaries, and a savings in postage. All other disbursement items, with slight over/under differences, very closely approximated estimated expenditures for the year.

In the year ahead, with no large expenditures anticipated for non-renumerative activities or printing, it is confidently anticipated that the Association will wind up the year in the black with a slight excess of receipts over disbursements. This situation can prevail only if the membership continues on its present high plane, or is increased, and there is continued high revenue from advertising in the Association's Bulletins, and the demand for the Association's publications remains constant, or if sales are augmented. I am sure that the officers of the Association will make every effort to hold down disbursements, and with the continued support of its members, and the railroads, I am sure that the slight excess of receipts over expenditures anticipated for 1965 will be realized. Thank you. [Applause]

President Burris: Thank you, Mr. Hillman. It is certainly gratifying to know that the financial affairs of our Association are in good hands.

Gentlemen, you have heard the report of the secretary and the treasurer. A motion is in order that these reports be accepted.

[A motion to accept the reports of the secretary and treasurer was duly made, was seconded, was put to a vote, and carried.]

President Burris [Continuing]: I want now to recognize one of the men sitting at my left whom I skipped over previously, and give him an opportunity to bring greetings from the National Railway Appliances Association.

One time, when I was a young engineer, I had a request from the then president of the road that I worked for to ride to Chicago on an official car. There was a group of men in the car with us, and I heard the president say, "My office door is always open to a manufacturer's representative, first because he can't live without us and secondly because we can't get along without him."

That is the way I feel about the group that has the display on the floor above. Without further ado, I should like to call on W. A. Enstrom, president of the National Railway Appliances Association, for a few words.

Greetings from NRAA

W. A. Enstrom: President Burris, members of the American Railway Engineering Association, and guests:

It is my privilege to appear before you as a representative of the National Railway Appliances Association and to reaffirm that our members enjoy the close and cordial relations that exist between our Associations and have existed for these many years.

We welcome you to this outstanding exhibit hall, which is acclaimed the finest in the country. We in NRAA appreciate that you have scheduled your meetings here in concurrence with the largest and best exhibit NRAA has sponsored to date. We hope you will find time during your meetings to visit these exhibits and acquaint yourselves with the many new and important technological developments incorporated in the railway appliances and equipment on display.

We are certain that with your interest and cooperation this show will be equally as successful as the previous show in March 1961 proved to be.

On behalf of all the members of the National Railway Appliances Association, we earnestly extend congratulations and best wishes for the success of your 64th Annual Convention. Please come to see us at the exhibits.

Thank you. [Applause]

President Burris: Thank you, Mr. Enstrom. I know you have a good exhibit because I saw it, if only for a short time, yesterday.

I want now to call upon the other man whom I skipped a few minutes ago.

The outstanding feature of our opening session is the Keynote Address by an outstanding member of our profession and our industry. If I were to take the time to read all the material I have before me that gives all the different jobs the speaker has had, and the work he has done, we would be here long after the time set for lunch. However, I shall brief a few of the things.

The speaker was born in Phillipsburg, Kan., and was graduated from the University of Illinois with a Bachelor of Science degree in railway civil engineering. He began his railroad career on the Pennsylvania in 1934 at Philadelphia, and kept climbing up the ladder. His climb was interrupted when he joined the armed forces during World War II. He attained the rank of Major in the military railroad service, and was discharged in 1946. He then returned to railway service as engineer maintenance of way on the Great Northern at St. Paul. He was made chief engineer of this road in 1954. In 1956 he joined the New York Central as assistant vice president—engineering, subsequently being promoted to assistant vice president operations, assistant to president, and vice president. He was serving in the latter capacity in Washington, D. C. at the time of his appointment as vice president of the Operations and Maintenance Department, Association of American Railroads.

During these years he was very active as a member of AREA, having joined in 1939. He served on Committee 1—Roadway and Ballast, from 1947 to the present time. He served a three-year term as director of the Association, beginning in 1956.

With this background and as the head of the largest single department in the Association of American Railroads, in which the AREA functions as the Engineering Division, our speaker is eminently well qualified, and has chosen as his subject, "Where Do We Go From Here?"

Gentlemen, it is my pleasure to give you Rex R. Manion. Mr. Manion. [Applause]

Where Do We Go From Here?

By R. R. MANION

Vice President, Operations and Maintenance Department,
Association of American Railroads

Thank you, Mr. Burris. When someone goes through the list of places I have been and things I have been involved in, I am impressed with the fact that the day of the boomer must not be over.

Mr. Burris, fellow members of the AREA, directors and guests:

It gives me great pleasure to bring greetings from Dan Loomis, and his very best wishes for a successful and meaningful convention here this year.

I am both honored and pleased to appear as the keynote speaker for your Annual Convention this year. While this is the first time I join you as an official of the Association of American Railroads, it is by no means the first meeting I have attended—and like the rest of you, I have always left a better-informed railroader than when I arrived. So, it is with the aim in mind of trying to contribute a little to the end results of these sessions that I appear here again.

To help do this, I would like to have you project your thoughts back to those early days of railroading of 135 years ago when the first crude locomotives with their upright boilers rolled down a makeshift track to launch an area of industrial innovation and continental expansion which had never been seen before and, in the geographical sense, can never be seen again. Those first railroaders spearheaded the development of a whole cross-section of applied science and technology that, like an avalanche, piled up and spread outward into virtually every field of endeavor and foreshadowed today's accelerating mechanization, nuclear technology and automated controls.

Starting with a bare slate, the railroad engineers of our past surmounted awesome barriers to build an industry which became the standard for railroads throughout the world. They sought out and applied to railroading new techniques and new knowledge wherever these could be found and thereby brought this growing nation and its booming industries a fabulous transportation system, whose component parts were continually improved to meet the new needs of each succeeding era, resulting finally in the modern diesel-electric locomotive, domed passenger and smooth-riding freight cars, the electronic classification yard, centralized traffic control and intricate machines for working on track and roadway.

This never-ending, ever-rewarding process of refining every detail in the marvelous machine we call a railroad goes on today with unparalleled intensity—to such an extent that I wonder, gentlemen, if railroad technology may now be reaching a turning point. That is, while we continue to improve existing equipment and traditional ways of doing things, should we now start thinking in terms of wholly new approaches and the great new goals that swiftly advancing technology makes possible?

A related question we might also ask is, are we now doing enough in research and development to get ready to meet this nation's freight transportation requirements 5 years—10 years—20 years from now? Are we even assembling enough information to get an idea of what these future needs might be—and how this information may effect transportation needs and railroad opportunities?

Put another way, is railroad technology and the application of known technology to railroading advancing fast enough to cope with rising internal costs and the complex external problems posed by a rapidly growing population, shifting centers of production, congestion of highway and airway arteries, unequal competitive conditions and our nation's crucial struggle to halt waste and remain competitive in overseas markets?

I raise these questions not as academic exercises but as statements of the practical issues before the railroad industry and all America. It appears to me that railroads are heading into an era of rising demands for their freight services that will dwarf present traffic loads. This growing nation will soon be depending on railroads as never before to carry the bulk of its production load, and we must not fail to respond. It will be largely up to railroad engineering and operating men to spearhead this response, for only they can gear up railroad plant to meet this mountainous test.

To achieve perspective on the shape of the railroads' technological future, let's look at the present over-all picture. A revolution of change is occurring on today's railroads, and this is made up of four intermeshing aspects—changes in technology, the organization structure, work practices and pricing. Our focus today will be on technology—the changes in plant, facilities, equipment, operating methods and services. At the same time we must keep in mind the interaction of these changes with those aimed at streamlining the railroad network through mergers, at updating wasteful work rules and at overhauling our freight service pricing structure. I wish I could also cite changes occurring in a fifth essential area—that of government policies—yet all I can say in this respect is that the *need* remains as great as ever for legislative changes aimed at equalizing the competitive impact of government spending programs and ending outdated regulatory restrictions to allow railroads to pass on to the public the maximum benefits of technological improvements.

It is important that every railroader recognize this overall context in which he works, for one of our greatest opportunities lies in strengthening cooperation among all members of the railroad team—in recognizing the problems, designing our products, upgrading operating capabilities, and producing the kind of result that will please customers and attract business. Engineers and operation men are increasingly projecting their work in terms of its ultimate impact on service and the railroads' competitive position—in terms of customer needs for speed and dependability of delivery and the lowest reasonable prices.

You can get an idea of the opportunities ahead by extending into the future the trendline of the nation's growing economy and output. National production of goods and services last year increased in constant dollars by 4.6 percent, a good deal better than the postwar annual average of 3 percent. Last year also, railroad freight traffic volume rose by a healthy 6 percent. Now, even if railroads boost their freight load only by the economy's average annual expansion rate of 3 percent, (and we should aim to do better than that) their 1975 freight load would be ONE-THIRD greater than now. And by 1988, through compounding, it would DOUBLE!

Gentlemen, 1975 is just 10 years away: We ought to ask ourselves what we would do *right now* if railroads found themselves handling as much as a trillion ton-miles of freight a year instead of the present 660 billion ton-miles. Actually, it could happen sooner than we dare hope. How? Well, we've been talking in terms of railroad traffic growing only at the same pace as general economic expansion. But I for one do not think we need accept our present 43 percent of intercity freight traffic as the best share we can hope for. At the end of World War II the railroad share was 67 percent, and just a decade ago it was 50 percent. As railroads become increasingly competitive on services and prices, we could turn the tide against truck and barge competitors, just as they did for a generation against railroads. Three years ago railroads brought to a halt 18 years of decline in their share of intercity freight traffic. Today a competitive breakthrough is not out of the question. In any event, let's aim for that and aim high, and we may indeed hit the bull's eye!

The railroads' greatest aid in this match is, of course, their capital improvement program which has totalled $20 billion since War II's end and is forecast at a record-breaking $1.6 billion for this year alone. Combined with the newest marketing techniques, this improvement program is getting results in such traffic-capturing services as the piggybacking on flatcars of 2,000,000 truck trailers a year, the rack-car movements from auto factories of 3,500,000 new motor vehicles a year, the high-volume hauling of bulk goods in low-cost unit trains and a whole new breed of specialized and "jumbo" freight cars.

In these gathering improvements lie the vital elements for a great competitive breakthrough. Yet it won't be easy to bring this off. Frankly, I can't think of a more formidable test, not only because of intense service-price competition in the transportation marketplace but also as regards internal cost inflation. For instance, in the past decade, average prices of the supplies and materials railroads buy and use have risen 15 percent.

Far more serious, in the past 10 years railroads have seen their average employment costs per man rising at the rate of 5 percent on the average each year, and recent labor settlements indicate no let-up in this trend. To grasp the significance of a 5 percent annual employee cost increase, we need only note that because of compounding, average compensation per employee has risen by *65 percent* in the 10 years since 1954. While the average yearly wage rose by 55 percent from $4560 to the present $7066, health and welfare and various fringe benefits more than TRIPLED!

It is truly a great testament to your efforts that railroads managed at all to live under pressure of this constantly rising labor and materials bill. Equally remarkable, responding to the inroads of government-aided competitors, railroad revenues for hauling the average ton of freight a mile have been CUT 10 percent under the 1954 level.

But what about the future trend? What would happen if by 1975 we experienced *another* cumulative cost increase per worker of 65 percent? Imagine trying to cover that kind of increase by raising freight rates and passenger fares in today's competitive environment! No, that is no answer to this dilemma, though the strain may become so severe that some prices may indeed be affected. We can hope union officials will recognize the problem they're creating and restrain their demands. Yet much of the answer seems to me to lie in the hands of the engineer and operating man—in holding internal costs down by so improving operating efficiency and service that we can hope for competitive traffic gains to help bear the burden.

Our job is cut out for us. How do we do it? Can we count on any massive technological breakthrough as was provided in the first postwar decade by dieselization of motive power? Well, we are now involved in the development and application of several important and highly promising innovations. At the same time, we must continue our efforts toward the improvement of all aspects of our familiar environment, the solution of long-standing problems and the sensible adaptation of conventional methods to new or changing conditions. Let's look at some of them:

Roadway: Subgrade instability in some areas still plagues us and affects maintenance planning and costs as well as train operation and transportation efficiency. If we move into significantly higher train speeds, new appraisals will be required of grade and alignment standards and track spacing. Very high speeds will demand elimination of highway and street crossings at grade, concerning engineers not only with the technical problems but also the economic, government and public relations aspects of such a program. There also appear to be some interesting possibilities which may alter the practical limitations on grade and line improvements through the use in certain localities of atomic explosives, literally for moving mountains. Obviously, the exciting era of railroad construction did not pass on with the "Winning of the West."

Rail: Outstanding advances in both the design and quality of rail have taken place in the past several decades as a direct result of your efforts. Your tests and detailed experiments, both by the AAR Research Center and at other laboratories under industry sponsorship, along with cooperation from the steel industry, have eliminated certain kinds of rail failures and sharply reduced others. But we never are quite "home free." New elements are constantly introduced and raise new problems, such as higher freight car wheel loadings, more intensive use of tracks, higher train speeds, increasing material and labor costs, demanding further improvement in design, metallurgy, support and fastenings.

Rising adoption of the use of continuous lengths of welded rail is significantly improving rail life and reducing maintenance costs. With the laying of 2,400 miles of "long" rail last year, the total of continuous welded rail now in service has been boosted to over 11,000 miles. Even more refinement can be anticipated in welding techniques, including field closures, in stress equalization and containment, all of which points toward the near-universal application of welded rail to mainline tracks.

Rail Defect Detection: In step with improvements in rail quality has come the steady improvement of rail defect detection equipment, designed to locate and identify rail flaws in advance of service failure, and capable of faster rates of operation to make feasible increased frequency of testing to bring service failures to new lows.

Track Maintenance: One of the more dramatic changes in the engineering-maintenance picture during the postwar period has been the transformation of track and structure maintenance from mostly manned to mainly mechanized. And now you are moving into the new dimension, increasingly automated. The successful application of these changes has been responsible for this industry's remarkable record of being able to attain and retain a high degree of maintenance quality at an almost static cost level despite sharply rising labor and material prices. I join you in feeling proud of these accomplishments.

Ballast: Through the work of the AREA committee and the Research Center, and in collaboration with suppliers, specifications for track ballast have been markedly improved over the last two decades, contributing further to the reduction in the cost of track maintenance. The trend toward higher freight car axle loadings and greater train speeds lends new significance to the matter of track support. If exceptionally high speeds are adopted, particularly for passenger trains, different concepts of track support will merit study, with a view toward the possible adoption of some type of structure that will insure more precise control of line and surface.

Cross Ties: The intensive research, testing and support of improved treating methods and materials by the railroads and their cooperating industry groups have resulted in a progressive increase in the effective quality and life of cross ties. Together with research into concrete ties, as well as into the use of wood and wood products, we must also maintain our efforts to develop alternative materials or systems for rail support. Despite the development of mechanized means for replacing cross ties, the procedure is still an expensive one and may, in some cases, disrupt track surface unnecessarily; this suggests that we might not only keep in mind the possibility of producing cross ties from some new materials but also look for means to manufacture the substitute tie in place. Such a suggestion may sound a little "far out" but if we challenge ourselves with such ideas, we may be amazed at what can result.

Train Control and Signaling: One of the important developments in signal improvements has been the application of Centralized Traffic Control, which now covers about 34,000 route miles, or more than four times that existing in 1946. And an additional 1,700 route miles will probably be covered this year. CTC has been employed to improve train operations, increase the capacity of single track lines, forestall the need for double tracks where single tracks exist with increasing traffic, and to eliminate much mileage of multiple tracks where a single or double-track CTC system proved adequate to meet needs. Maintenance and tax costs have been greatly reduced by such applications, with traffic being handled even more expeditiously and efficiently. These systems are very closely related to the type of controls which could be used for automated or semi-automated train operations, and the possibilities of such uses in connection with advances being made in communications and computer programming open up some exciting vistas.

Communications: Application of new technology to railroading has probably advanced more rapidly in the field of communications than in any other during the last few years. Not only have railroads found ways to apply new technologies but they have been advancing the technologies themselves. These advances are changing the structure of transportation management and greatly boosting efficiency. New systems are being designed to handle both voice communication and data transmission, and in such a way as to avoid logjams in the transmission of data to computers and control centers.

Radio and microwave have combined to eliminate pole lines, and it is not too much to hope that such systems can even be applied to the transmission of signal circuits, eliminating signal wire lines. Microwave transmission systems have risen from a novelty 10 years ago to a present coverage of 7,000 miles of railway, and radio has expanded in railroad operations to present use of 3,500 base stations and 55,000 mobile units.

Terminal Operations: Terminals are not only the crucial points where trains are born and freight cars are exchanged and delivered, but are also the seat of some of the railroads' most complex service problems. In a concentrated effort to eliminate terminal delays and interchange complexities, railroads have installed 44 major electronic car classification yards since 1949 and improved scores of others. Marvels of push-button ingenuity, these modern yards are equipped with some of the most sophisticated control devices in the whole nation, utilizing all sorts of modern data transmission and processing devices, computers, radar, radio, TV, etc.

Systems of blocking in trains whole groups of cars going to one destination are on the rise to speed through-movements. Car interchange delays are also being reduced as the merger movement picks up speed; indeed, this speed-up in freight delivery may be a most important benefit from mergers.

The growing use of unit trains, bypassing intermediate yards in expedited through-movements, is another major operating and service improvement. In fact, the speed-up operating procedures now largely confined to unit trains should ultimately be extended to most volume traffic flows between major centers, achieving the faster movement of progressively greater loads with a fewer number of cars.

Data Systems: Data transmission systems are being employed or developed by transportation departments for many purposes—for car location, systemwide inventory of loads and empties (the empties being identified by types, capacity and even condition), for programming the movement of cars, planning the switching of trains in advance of their arrival in terminals and filling customer orders more promptly and with the right kind of equipment. Thus is being developed a management tool which promises greatly improved service and much better utilization of car equipment, a vital goal in view of the doubling of the average price of new freight cars in the past 10 years.

Automatic Car Identification systems can perhaps be developed for use along with such sophisticated information systems, giving needed speed and accuracy for the initial input into these systems, as well as providing means of checking car locations on an internal system basis where justified. Another useful employment of computers may come in a procedure to create models of train operations and test these mathematically to point up the effects of possible changes in operating procedures or facilities.

Scheduled Freight Services are resulting from all these developments. To meet customer needs for more dependability in rail deliveries of goods, freight trains are being run on passenger-type schedules in many locations and for many commodities. Unit train operations are one example. Also, many manufacturing parts shipments are being timed to meet the production-line needs of assembly plants a thousand and more miles away. Thus are railroads being integrated into the production chain as an extended plant conveyor-belt system, allowing manufacturers to reduce costly inventories and locate factories with a closer eye toward material, labor and market requirements.

Freight Cars: A virtual revolution in freight equipment is taking place as cars get bigger and more specialized to meet shippers' specialized needs. Average capacity of new freight cars is already 76 tons, compared with 50 tons for those being retired; and it looks as if the typical freight car of the 1970s will be in the 100-to-150-ton category. We are also apt to see some really big cars coming out as duplex or articulated units to better distribute wheel loads and still allow smooth movement around curves. Better springing and shock absorbers, coupling impact cushioning gear, brakes and roller bearings will be standard features of tomorrow's cars, as they are on the latest installations of today.

Hotboxes: In just two years, the number of freight cars equipped with roller bearings more than doubled, adding up to 157,000 as of last May. As roller bearings increase, and particularly as better designs and maintenance methods have been developed for standard journal bearings, phenomenal progress has been registered in reducing overheated journals. In this respect, I think the entire industry could pause and take its hat off to the AAR Research Center staff and the Mechanical Division for spearheading this remarkable progress. Cars set out from trains because of hotboxes are now down to one-sixth those experienced as recently as five years ago, and distance traveled by freight cars between set-offs has now risen to 1,250,000 miles. Further work gives promise of even *doubling* this mileage in the next few years. Heat detection equipment is proving itself an aid toward further progress, but we need to develop a means for *continuous* monitoring, accurately reporting heated bearings before they have a chance to become troublesome hotboxes.

Locomotives: The size of power units will continue to rise, just as the average diesel-electric unit being installed today is 2,500 hp, replacing the typical 1,500-hp units placed into service 15 and more years ago. A series of 5,000-hp diesels has been developed, and oil-burning gas-turbine units of 8,000 hp have gone into service. It is possible that once safe and efficient atomic units are developed, we will see locomotives of 10-to-15-thousand-hp size. However, because such massive units reduce the flexibility of locomotive utilization and impose enormous drawbar strain on the entire train, we are apt to see more remote-controlled power units being spaced through heavy, high-speed trains.

Nor should we dismiss future electrification potentials. Long strides are being made in power generating and transmission efficiencies, and if the merger movement brings a greater density of train movements on selected routes, we may see electricity feed systems become more economicaly justified—though this may have to wait until the next diesel replacement cycle.

Freight Train Speeds are also being stepped up further, with 75-mph "hot shots" likely one day for priority goods. Right now, of course, 60-mph freight trains are common, with some piggyback, merchandise and fresh-produce specials already reaching the higher figure cited. Actually, there is no *technological* reason why priority freight could not be moved at even 100-mph speeds; yet this would require an extravagant use of power, for it takes twice the power to move a train at 60 mph as 40. The point is, however, that we are apt to see a speed-up of freight train operations in the future that will make the wayside observer's eyes pop out.

In conclusion then, gentlemen, can anyone doubt the great promise and potentials railroadmen have in making their unique technology not only better serve the nation but also spearhead the thrust to a whole new era of railroad growth? The things I have outlined here today are visible and within reach. Yet we have really only skimmed the surface of opportunities. What about the promise of things that have not even occurred to us, that await around the corner, behind the next research development?

The answers are up to you experts, you engineers gathered here today. With your colleagues in other railroad technical and operating areas, you have contacts with universities and research groups and with the best brains in all fields throughout the country. You see the coming plant changes, the competitive inroads, the inflation in operating costs, the intensified pressure to build a greater country and to keep it great. To re-state the question we began with, with our knowledge, our insight, *are* we doing enough in technology? And what more can we do that we aren't doing now?

Well, one proposal you might consider lies in setting up a forward-planning group of your outstanding men—a group that would devote itself to weighing the technological opportunities of our future, to thinking out loud on how to get more out of present procedures and facilities, and originating and investigating new approaches.

Let us dare to do more long-range looking and bold and imaginative thinking—THREE-DIMENSIONAL THINKING, if you will—*thinking broadly* in terms of how our skills and knowledge can benefit over-all railroad operations and services, *thinking deeply* in terms of the ultimate benefits we can derive from every aspect of advancing technology, and *taking the long view* as to how our efforts can help guide transport progress and build a better railroad future.

Such approaches are bound to benefit the entire nation as well as the whole railroad family. And we just might come up with a world-beater—as well as a truck and barge beater! [Applause]

President Burris: Thank you, Mr. Manion, for this informative and stimulating talk. I hadn't seen your remarks before I drafted mine, and I am pretty sure you didn't see mine, either.

We are proud of the fact that Mr. Manion is a member of this Association and has now joined the Association of American Railroads as one of its vice presidents. We are proud in AREA of the relationship we maintain with the AAR, which relationship has existed since 1919 with benefit and credit to both AREA and the AAR. Thank you for your address and for meeting with us. [Applause]

It is now time to get into our program of committee reports and special features. I will ask those at the speaker's table to please take seats in the audience, because I am sure they will enjoy the program more from that location. Gentlemen, your presence at the speaker's table has been appreciated, and you are now excused.

Discussion on Engineering and Valuation Records

[For report, see Bulletin 589, pages 231–243]

President Burris: The first committee report to come before this convention is that of Committee 11—Engineering and Valuation Records, the chairman of which is M. C. Wolf, valuation engineer, Northern Pacific Railway. Will Mr. Wolf and the members of his committee please come to the platform.

While the members of the committee are coming to the speaker's table, I will ask that the chairman, vice chairman, secretary and all reporting subcommittee chairmen take seats as close to the podium as possible. The other members of the committee will find places at each end of the table. This will reduce the time required for subcommittee chairmen to come to the podium to give their reports.

As a convenience and time-saving expedient, we have provided the chairman with a microphone so that he can make such introductions and comments as he desires without coming to the podium microphone.

Gentlemen, this is your convention; so, before I turn the meeting over to Chairman Wolf, I want to extend to each of you the privilege of the floor, and invite your comments on, or criticism of, any of the report presentations within the time which can be allowed for discussion. When you desire to speak, please address the Chair and state your name and railroad clearly for the benefit of our reporter, so that you will be correctly identified.

Mr. Wolf, you may now proceed.

Chairman M. C. Wolf: Mr. President, members of the Association and guests:

The report of Committee 11—Engineering and Valuation Records, appears in Bulletin 589, December 1964, pages 231 to 243, incl. This committee has eight assignments upon which we should like to comment briefly.

Assignment 1—Revision of Manual

Chairman Wolf: A thorough revision of our chapter of the Manual is under consideration, but no report is submitted. I should like to have the subcommittee chairman rise and be recognized. He is John L. Manthey, auditor of capital expenditures, Elgin, Joliet & Eastern Railway.

Assignment 2—Bibliography on Subjects Pertaining to Engineering and Valuation Records

Chairman Wolf: The report on this assignment will be given by Chairman J. Bert Byars, assistant to chief engineer, Denver & Rio Grande Western Railway.

J. Bert Byars: Mr. President, the report of Subcommittee 2 appears on page 232 in AREA Bulletin 589 of December 1964.

This report makes reference to articles from publications printed during the past year as well as publications of the past which pertain to the "paper work", so to speak, in connection with engineering and maintenance on the railroads today.

It is the intent of our committee to call your attention to these articles so that you may read them in an effort to keep your heads above water in dealing with your accounting department, the Interstate Commerce Commission, an outside agency, and the holders of the purse strings on your respective railroads.

Assignment 3—Office and Drafting Practices

Chairman Wolf: The study of microfilming of records continues, but no report is submitted. W. A. Krauska, assistant engineer, Missouri Pacific Railroad, after serving effectively and faithfully in the capacity, has resigned as chairman of the subcommittee. I should like to have the new chairman rise and be recognized. He is Charles H. Rapp, assistant supervising engineer, Pennsylvania Railroad.

Assignment 5—Use of Statistics and Data Processing in Railway Engineering

Chairman Wolf: This subcommittee has two co-chairmen. The report on this assignment will be given by co-chairman Howard R. Williams, valuation engineer, Union Pacific Railroad, who is in charge of the engineering phase of the assignment, and who also is vice chairman of Committee 11.

Howard R. Williams: Committee 11 welcomes the opportunity of participating in the research on the application of these modern-day techniques to the railroad industry. The results of our computer study this past year is represented by a progress report on the engineering phases of data processing of construction reports. This appears on page 234 of Bulletin 589.

Basically, we have attempted to report on the theory and practice of converting manual AFE or work-order property accounting procedures to computers. To do this we considered a number of specific railroad applications, grouped the methods being utilized into three general categories, and outlined the characteristics of each. We have tried to place the emphasis on the engineering aspects involved.

Chairman Wolf: I should like to have the other co-chairman rise and be recognized. He is William J. Pease, assistant general auditor, Illinois Central Railroad, who is in charge of the accounting phase.

I also wish to present the newly appointed successor to Mr. Williams as co-chairman, Harold C. Boley, valuation engineer, Atchison, Topeka & Santa Fe Railway.

Assignment 6—Valuation and Depreciation

Chairman Wolf: The report on this assignment will be given by Chairman Chester R. Dolan, engineer capital expenditures, Missouri Pacific Railroad.

C. R. Dolan: The committee report covering Assignment 6 makes mention of the Elements of Value for all Class I line-haul, and switching and terminal companies to be issued by the Interstate Commerce Commission. The Elements of Value as of December 31, 1963, were issued by the Commission in January 1965, and at that time, notice was issued to the effect that the Interstate Commerce Commission would no longer prepare and release the Elements of Value statements.

The Interstate Commerce Commission will, however, continue to maintain the original cost of properties for all carriers as in the past; and through the functions of the Railroad Advisory Committee on Equipment and Property, will continue to issue the annual railroad construction indices, which are widely used.

Assignment 7—Revisions and Interpretations of ICC Accounting Regulations

Chairman Wolf: The report on this assignment will be given by Chairman Robert D. Igou, engineer capital expeditures, Chicago, Rock Island & Pacific Railroad.

R. D. Igou: Since the publication of this report, the ICC has issued three additional Orders as follows:

1. Under Docket No. 32153 on December 17, 1964, the Commission issued certain amendments to the Uniform System of Accounts for railroad companies pertaining to property retired from service, which property previously was subject to amortization accounting.
2. Under Docket No. 34477 on January 8, 1965, the Commission revised the Classification of Carriers for Reporting Purposes by designating carriers having annual operating revenues of $5,000,000 or more as Class I, and carriers having annual operating revenues of less than $5,000,000 as Class II.
3. Under Docket No. 32153 on February 11, 1965, the Commission further amended the General Instructions of the system of accounts pertaining to classification of carriers to give effect to the revised designation of carriers as between Class I and Class II.

The Bureau of Accounts of the Interstate Commerce Commission issued January 4, 1965, Case 132, an interpretation of the correct accounting for transactions relating to equipment and other property subject to amortization accounting transferred to another company and reacquired under lease or purchase agreement.

Assignment 8—Instructions for Making Engineer Field Checks and Their Application to Completion Reports

Chairman Wolf: Further report on this assignment is being held in abeyance pending the revision of ICC requirements. I should like to have the subcommittee chairman rise and be recognized. He is Carlton F. Olson, valuation engineer, Great Northern Railway.

Assignment 9—Simplification of Annual Reports on Form 588 to the Interstate Commerce Commission, and Underlying Completion Reports

Chairman Wolf: Because drastic changes in the Commission's requirements are under consideration, no report on this assignment is now offered. The subcommittee chairman is unable to be with us today. He is Frank A. Roberts, valuation engineer, Erie Lackawanna Railroad.

Are there any questions or suggestions regarding our report?

Mr. President, this concludes the report of Committee 11, my final report as chairman. It is a privilege to belong to the Association, to serve on Committee 11, and particularly to be honored with the chairmanship. I thank all of the members of the committee for their loyal support and for the pleasure of working with them. Thanks also are due to the officers of the Association and to the executive secretary's staff for their encouragement and for their interest in our work.

Mr. President, I should like to present the new chairman and vice chairman of Committee 11. Both of them are earnestly devoted to the work of the committee. The new vice chairman is J. Bert Byars, assistant to chief engineer of the Denver & Rio Grande Western Railroad. The new chairman is Howard R. Williams, valuation engineer, Union Pacific Railroad.

President Burris: Thank you, Mr. Wolf, and the members of your committee, for the further valuable work of your committee. Mr. Wolf, we appreciate your able leadership of Committee 11 for the past three years. As you are relieved of your responsibilities as chairman we welcome the new chairman, your successor, Mr. Williams. We are satisfied that he has worked with you long enough to have assumed some of your good qualities as chairman and leader, and we are looking forward to his carrying on your work.

Mr. Williams, as a symbol of your new authority, and to assist you in conducting the meetings of your committee, I would like to present you with this chairman's gavel. The inscription reads, "H. R. Williams, Chairman, AREA Committee 11, 1965–1967."

Mr. Wolf, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Ties and Wood Preservation

[For report, see Bulletin 589, pages 225–230]

President Burris: The next committee to report is Committee 3—Ties and Wood Preservation. Will the members of this committee proceed to the platform, please.

Again I request the officers of all committees and all reporting subcommittee chairmen to take places nearest to the podium. Again I would remind everyone present that you have the privilege of the floor to comment on, or ask questions with respect to, any aspects of the committee's report.

I am pleased to turn the meeting over to the chairman of this committee—W. E. Fuhr, assistant chief engineer, signals and communications, Chicago, Milwaukee, St. Paul & Pacific Railroad.

Chairman W. E. Fuhr: Thank you, Mr. President.

The report of Committee 3—Ties and Wood Preservation, appears in Bulletin 589, pages 225 to 230, incl.

Assignment 1—Revision of Manual

Chairman Fuhr: The work on Assignment 1—Revision of Manual, is being carried on currently. The subcommittee has come up with a few changes, mostly editorial, which will be submitted next year. The chairman of the subcommittee is C. S. Burt, assistant to vice president, purchases and stores, Illinois Central Railroad.

Assignment 2—Cross and Switch Ties

Chairman Fuhr: I should like to call upon H. F. Kanute, engineer layout and design, St. Louis–San Francisco Railway, chairman of Subcommittee 2, for his report.

H. F. Kanute: During the month of June 1964, Committee 3 inspected ties in one tie yard in Illinois. The ties observed were of excellent quality, red and white oak, sizes 2, 3, 4 and 5, 8 ft 6 in long. Sizes 2 and 3 were stacked together as were sizes 4 and 5.

All ties were stacked for seasoning in accordance with AREA Manual recommendations. The ties were acceptable as to AREA size classification. The yard was clean and well drained.

The following report on possible revision of cross tie design and/or spacing (standardization of cross ties) is based on replies received from 24 railroads representing all sections of the United States and Canada and the tie treating industry as represented on Committees 3 and 5.

At present most railroads use size 2, 3, 4 and 5 ties; a few use size 1 for light industry tracks. Sizes 4 and 5 are usually piled together and used for principal and secondary main lines and sizes 2 and 3 are piled together and used for all other types of tracks. Thus for track use it appears that two or possibly three sizes of ties would in most cases provide satisfactory sizes for most railroads. However, to specify the quality of ties to be purchased and to fully utilize the tie timber available, the sizes as now specified are desirable.

There is a trend by railroads toward selective doweling of ties. However, we find a variation in the use of anti-splitting devices—from none for vapor-dried ties, to selective use of "C" or "S" irons, to full utilization of dowels for all ties.

Fifty percent of the railroads reporting are not now adzing ties. Most railroads are boring for spikes; however, four railroads report no adzing or boring and three report boring for better penetration of preservative and drainage under tie plates without regard to spike holes.

Treatment solutions and retentions for creosote-coal tar solutions vary throughout the United States depending on species, climatic conditions and the consistency of the coal tar which is produced as a by-product and for which we have no specifications. We do have greater standardization of treatment where creosote-petroleum solutions are used.

With so many variables involved, it is almost impossible to standardize on treatment solutions and retentions in the United States.

In Canada, the two major railroads use tie sizes 2, 3 and 5, 8 ft long, make their own application of anti-splitting devices, treat ties with a 50/50 creosote–petroleum solution, retention 7 lbs per cu ft, and prebore 4 to 6 holes for spikes. Greater standardization is possible in Canada because the climatic conditions are similar for all roads and the same species and treatment products are available at economic prices.

One tie-treating company stated that the railroads could do more to keep the prices of ties from rising by establishing a constant buying level throughout the year, than any other one thing they could do.

This is a progress report, submitted as information.

Assignment 3—Wood Preservatives

Chairman Fuhr: There is no report on Assignment 3 this year, but I do want to recognize the chairman of the subcommittee, W. W. Barger, chief inspector, Tie and Timber Treating Department, Atchison, Topeka & Santa Fe Railway. Thank you, Mr. Barger.

Table 1 (Cont'd)-Specific Requirements for Preservative Treatment by Pressure Processes (Piles)

		Southern Pine Ponderosa Pine		Pacific Coast Douglas Fir		Oaks	
CONDITIONING		Air-seasoning, accelerated air-seasoning, steaming or heating in the preservative or a combination.		Air-seasoning, accelerated air-seasoning, heating in the preservative or a combination.		Air-seasoning, accelerated air-seasoning, or heating in the preservative or a combination.	
Steaming							
Temp.-deg F-max		245		Not permitted		Not permitted	
Duration-hr-max		20*					
Vacuum							
Inches at sea level-min		22					
Heating in preservative							
Temp.-deg F-max		220		220		220	
TREATMENT							
Creosote-type preservatives		Empty or full-cell		Empty or full-cell		Empty or full-cell	
Pressure-psi-max		200		150		200	
Final steaming							
Temp.-deg F-max Duration-hr-max		Not permitted		Not permitted		Not permitted	
RESULTS OF TREATMENT		(Gen. Use)	(Coastal Waters)**	(Gen. Use)	(Coastal Water)**	(Gen. Use)	(Coastal Waters)**
Retention-lb. per cu. ft-min.							
Sampling zone for assay inches from surface		0-3.0	0-3.0	0-2.0	0-2.0	0-2.0	
Number of borings per charge		20		20		20	
Creosote-type preservatives							
Creosote	by Assay	12	25	10	20	8	10
	by Weight	12	Ref. min. 20	8	Ref. min. 12	8	Refusal full-cell
Creosote-coal tar	by Assay	12	25	10	20	8	10
	by Weight	12	Ref. min. 20	8	Ref. min. 12	8	Refusal full-cell
Creosote-petroleum	by Assay	15	Not recommended	12	Not recommended	8	Not recommended
	by Weight	15	Not recommended	10	Not recommended	8	Not recommended
Pentachlorophenol	by Assay	.6	Not recommended			(Above retentions for red oak only. White oak treated to refusal for all uses.	
	by Weight	.5	Not recommended				
Penetration in inches or percent of sapwood-min.		3.5" or 90% for 12 to 16 lb. retention 4.0" or 95% for 17-24 lb. retention		0.75" for 8-lb. retention. For 10-lb. retention - 0.75" and 85% up to a max. of 1.625" for heavier retention.		White oak-100% of sapwood Red oak-65% of annual rings; Charges of recalcitrant wood with less penetration may be accepted if wood is conditioned properly before treatment and treatment is continued to refusal.	
Determination of penetration		A borer core shall be taken mid-way between the butt and top of each pile in each charge. Only those piles meeting the penetration requirements shall be accepted.		A borer core shall be taken mid-way between the butt and top of each pile in each charge. Only those piles meeting the penetration requirements shall be accepted.		A borer core shall be taken approximately 4 ft. from the butt end of each pile in each charge and only those piles meeting the penetration requirements shall be accepted.	

* Total steaming time including pretreatment, conditioning and final steaming should not exceed 20 hours.

** Subject to marine borer attack.

Assignment 4—Preservative Treatment of Forest Products

Chairman Fuhr: The report on Assignment 4 will be given by L. C. Collister, manager, Tie and Timber Treating Department, Atchison, Topeka & Santa Fe Railway.

L. C. Collister: In addition to the brief report in the Bulletin, we are presenting as information a proposal to include the assay method of determining retention of preservatives in poles and piling as an alternative to the measurement of retention by tank gage or scale weights. That part of Table 1 of Specifications for Treatment, Chapter 17 of the Manual, pertaining to piles and poles is presented herewith as information (see above and on page 610), corrected to include the assay method.

Measuring retention by gage or by weighing is the best method to control plant inventory, but it is not the best method to determine the future performance of the treated material. We hope to present this material next year for inclusion in the Manual.

Assignment 5—Service Records of Forest Products

Chairman Fuhr: The report on Assignment 5 will be given by Subcommittee Chairman W. F. Arksey, engineer water service and fuel facilities, Great Northern Railway.

Table 1 (Cont'd)-Specific Requirements for Preservative Treatment
by Pressure Processes
(Poles)

		Southern Pine Ponderosa Pine	Jack Pine	Red Pine	Lodgepole Pine	Pacific Coast Douglas Fir	Intermountain Douglas Fir Western Larch
CONDITIONING		Air-seasoning, accelerated air-seasoning, steaming or heating in the preservative or a combination.	Air-seasoning, accelerated air-seasoning, steaming or heating in the preservative or a combination.			Air-seasoning, accelerated air-seasoning, or heating in the preservative or a combination.	
Steaming							
Temp.-deg F-max		245	240			Not permitted	
Duration-hr-max		17	3				
Vacuum							
Inches at sea level-min		22	22				
Heating in preservative							
Temp.-deg F-max		220	220			220	
TREATMENT							
Creosote-type preservatives		Empty or full-cell	Empty or full-cell			Empty or full-cell	
Oil-borne preservatives		Empty or full-cell	Empty or full-cell			Empty or full-cell	
Pressure-psi-max		200	150			150	
Final steaming							
Temp.-deg F-max		245	240			240	
Duration-hr-max		2	3			3	5
RESULTS OF TREATMENT							
Retention-lb. per cu.ft.-min							
Sampling zone for assay inches from surface		0.5-2.0	0.1-0.75				
Number of borings per charge		20	20			20	
Creosote-type preservatives							
Creosote	by Assay	6	12	8	12		
	by Weight	8	6	6	6	8	
Creosote-coal tar	by Assay	6	10	8	12	--	
	by Weight	8	6	6	6	Not recommended	
Creosote-petroleum	by Assay	Not recommended	Not recommended			Not recommended	
	by Weight	10		8		10	
Oil-borne preservatives							
Pentachlorophenol	by Assay	0.3	.6	.4	.6		
	by Weight	0.4	.3	.3	.3	0.4	
Penetration in inches or percent of sapwood-min.		2.5" or 85%, 3.0" or 90% 3.5" or 90% for 8, 10 and 12 lb. retention, respectively for creosote, creosote-coal tar or for 0.4, 0.5, 0.6 lb. retention respectively of Pentachlorophenol.	1.5" or 85% for jack and lodgepole pine. 2.5" or 85% for red pine.			P.C.Douglas fir-0.75" for 8 lb. retention and 85% up to a max. of 1.625" for heavier retentions. Interm.Douglas fir-0.5" and 70% Western Larch 0.50" and 70%.	
Determination of penetration Group A--poles whose 6 ft. from butt circumference is less than 37.5 in.		A borer core shall be taken mid-way between the butt and top of 20 poles in each charge. If 18 of the borings meet the penetration the Group A poles in the charge as a whole shall be accepted but the non-conforming poles in the sample shall be retreated. If 16 or 17 of the borings meet the requirements each Group A pole in the charge shall be bored and only those meeting the requirement shall be accepted. If less than 16 of the borings meet the requirements all Group A poles in the charge shall be rejected.				A borer core shall be taken mid-way between the butt and top of 20 poles in each charge. If 18 of the borings meet the penetration the Group A poles in the charge as a whole shall be accepted, but the non-conforming poles in the sample shall be retreated. If 16 or 17 of the borings meet the requirements each Group A pole in the charge shall be bored and only those meeting the requirement shall be accepted. If less than 16 of the borings meet the requirement all Group A poles in the charge shall be rejected.	
Group B--poles whose 6 ft. from butt circumference is 37.5 in or more.		A borer core shall be taken mid-way between the butt and the top of each pole and only those meeting the penetration requirement shall be accepted.				A borer core shall be taken mid-way between the butt and the top of each pole and only those meeting the penetration requirement accepted.	

W. F. Arksey: The report of your committee again gives the annual statistics on tie renewals for the previous year. Renewals for 1963 were slightly above 1962, approaching closely the five-year average.

The termite investigation is now 92 months old. The report on last year's inspection after 76 months of exposure is printed in the December 1964 issue of the Bulletin. The inspection at the end of the 92-month period was made by members of your committee and other interested treating men on February 8 and 9, 1965. We thank all who participated this year and invite those interested to come with us next year. Gainesville gave us very nice weather this year, so I should give their Chamber of Commerce a little plug.

Assignment 6—Collaborate with AAR Research Department and Other Organizations in Research and Other Matters of Mutual Interest

Chairman Fuhr: There is no formal report on Assignment 6 this year, but I do want to recognize the subcommittee chairman, P. D. Brentlinger, forester, Pennsylvania Railroad. Thank you, Mr. Brentlinger.

Mr. President, this completes the report of Committee 3. Are there any questions from the floor? If not, thank you for your attention.

President Burris: Thank you, Mr. Fuhr. We appreciate your committee keeping us up to date on this very important aspect of our work. You and your Committee are now excused with the thanks of the Association. [Applause]

Discussion on Clearances

[For report, see Bulletin 589, pages 245–256]

President Burris: We will now hear from Committee 28—Clearances, the chairman of which is R. L. Williams, office manager, Engineering Department, Illinois Central Railroad, Chicago. Will Mr. Williams and the members of his committee now come to the platform. Mr. Williams, you may proceed.

Chairman R. L. Williams: Mr. President, members of the Association and guests:

Your Committee 28 reports on seven assignments for the past year. We shall now give just the highlights of the reports except for those presenting specific recommendations to the Association. For more complete details please refer to Bulletin 589, December 1964, Vol. 66, pages 245 through 256.

Assignment 1—Revision of Manual

Chairman Williams: B. Bristow, principal assistant engineer, Chicago, Rock Island & Pacific Railroad, Chicago, chairman of the subcommittee, will now give his report.

B. Bristow: Mr. President, members of the Association and guests:

Your committee has reviewed Part 3—Equipment Diagrams, of Chapter 28 of the Manual and submits for adoption the recommendations outlined on page 246 of Bulletin 589, as follows:

Page 28–3–1—Delete Fig. 1 and substitute therefor revised Fig. 1—Equipment Diagram Unrestricted for Interchange Service.

Following page 28–3–1, add the following new diagrams:

Fig. 2—Maximum width of cars with various truck centers.
Fig. 3—Equipment diagram for limited interchange service.
Fig. 4—Maximum width of cars with various truck centers.
Fig. 5—Outline diagram for single loads, without end overhang, on open-top cars.

These five figures are the same as the equipment diagrams of the Mechanical Division, AAR, and are recommended for adoption and publication in the AREA Manual for convenient reference only.

Mr. President, I move the adoption of these revisions to the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 2—Compilation of the Railroad Clearance Requirements of the Various States

Chairman Williams: There is no report on this assignment at this time. A thoroughgoing canvas is currently in progress to disclose any revisions to the Clearance Chart that may have arisen since its last publication. R. D. Erhardt, junior engineer, Gulf, Mobile & Ohio Railroad, Mobile, Ala., is chairman of this subcommittee.

Assignment 3—New Methods and Electronic Devices for Recording Measurements of Clearances of Structures Along Right-of-Way and Overall Dimensions of Cars and Loads in Yards and at Interchange Points, Looking to the Possible Use of a Computer Program for Routing High and Wide Loads

Chairman Williams: A preliminary report was published in Bulletin 582, December 1963, Vol. 65, pages 341 and 342, and reported to the Association last year. The subcommittee chairman at that time was absent because of illness and subsequently resigned. This has badly delayed progress on the assignment. F. B. Persels, office engineer, Missouri Pacific Railroad, St. Louis, Mo., is the newly appointed chairman of this subcommittee.

Assignment 5—Clearance Allowances to Provide for Vertical and Horizontal Movements of Equipment Due to Lateral Play, Wear and Spring Deflection, Collaborating with the Mechanical Division, AAR

Chairman Williams: There is no report on this assignment at this time. We are awaiting further road tests of auto-carrier cars and other types of cars in piggyback service. At the present time certain tests on large box cars are being carried forward on the Illinois Central for the AAR Joint Committee on Relation between Track and Equipment, and may furnish additional information to this committee along the lines of its assignment. E. E. Mills, draftsman, Pennsylvania Railroad, Chicago, is chairman of this subcommittee.

Assignment 6—Feasibility of Formulating a More Complete Method, for Use of Transportation Departments, in Reporting Loads of Excessive Dimensions to Minimize Necessity for Requesting Additional Information, Collaborating with the Mechanical Division, AAR

Chairman Williams: A basic draft of required information has been developed and has been circularized to the full membership of Committee 28 for further recommendations. When ready the results will be forwarded to the AAR Mechanical Division for its review before being presented to the Association. J. E. Beran, draftsman, Chicago, Burlington & Quincy Railroad, Chicago, is chairman of this subcommittee.

Assignment 8—Review Present Methods of Presenting Published Clearance Information

Chairman Williams: J. A. Crawford, assistant engineer, Chesapeake & Ohio Railway, Huntington, W. Va., chairman of the subcommittee, will give his report.

J. A. Crawford: Part (a) of this assignment is: "Review present methods of presenting published clearance information to determine how this can be simplified and/or standardized."

Your committee has developed and now recommends for adoption and publication under Miscellaneous, Chapter 28 of the Manual, the "Suggested Method of Presenting Published Clearance" shown in Bulletin 589, December 1964, pages 252–255, incl.

Mr. President, I move that this "Suggested Method of Presenting Published Clearance" be adopted.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Crawford: Part (b) of this assignment is: "Review present methods of presenting published clearance information to determine the feasibility of including in the Official Railway Equipment Register the light weight and height of center of gravity of all heavy-duty flat cars to aid clearance personnel in routing shipments of excessive weight."

Your committee is working through the Secretary's office on this, and has furnished the Secretary's office with information for its use in negotiating this subject with the publisher of the Official Railway Equipment Register. The future status of this matter will depend upon the outcome of these negotiations.

Assignment 9—Review Clearance Records of Various Railroads, Looking to Developing a Standardized Method for Charting All Obstructions

Chairman Williams: M. E. Vosseller, senior draftsman, Central Railroad of New Jersey, Jersey City, N. J., chairman of the subcommittee, will give this report.

M. E. Vosseller: Mr. President, Mr. Chairman, members of the Association and guests:

All members of the committee were requested to submit a copy of the clearance diagram currently in use by their respective employers. Copies of these charts were then distributed to the members for their review and comments. Suggestions and comments offered by the subcommittee, and later by the full membership of Committee 28, resulted in the development of a "standardized" chart. This chart incorporates the salient items of information submitted from the field to show the various obstructions influencing the movement of shipments of excessive width and height. Other data considered most generally useful to personnel responsible for clearing high and wide loads are also shown. Such a chart would be required for each district, division, area, etc., over which high and wide loads would be routed between yards, interchange points, etc.

By letter ballot Committee 28 approved the chart, which was subsequently published on page 256, Bulletin 589, December 1964, Vol. 66.

Mr. President, it is the recommendation of Committee 28, and I so move, that the chart be adopted by the Association for inclusion in the Manual as "Suggested Method for Charting All Obstructions" for guidance of the railroads in the charting of their obstructions. It is understood that individual roads differ in their standards and requirements pertaining to clearance records, and the form of the chart may be modified to best fit their particular needs.

[The motion was duly seconded, was put to a vote, and carried.]

CHAIRMAN WILLIAMS: Unless there are questions or comments on this report, Mr. President, this concludes the report of Committee 28.

PRESIDENT BURRIS: Thank you, Mr. Williams. Your committee has done an excellent job on subjects that are very important to the railroads, especially relative to moving the high and wide shipments of today. We know that you will continue your aggressive work during the coming year.

Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Economics of Railway Labor

[For report, see Bulletin 589, pages 257–271]

PRESIDENT BURRIS: We shall now hear from Committee 22—Economics of Railway Labor. The chairman of this important committee is M. S. Reid, assistant chief engineer—maintenance, Chicago & North Western Railway, Chicago.

For the record, and to give Mr. Reid the proper recognition he deserves, it should be noted that he took over the reins of this committee late in May 1964, after the former chairman resigned because of retirement from active railroad service. Mr. Reid, we want to thank you for your willingness to take over the guidance of this committee in midstream, so to speak.

At the same time, H. W. Kellogg was appointed vice chairman of the committee. Mr. Kellogg is assistant chief engineer maintenance of way, Chesapeake & Ohio Railway, Huntington, W. Va.

Will Mr. Reid and the members of Committee 22 please come to the platform. Again, I remind the subcommittee chairmen who will be making reports to take seats nearest the podium. Mr. Reid, you may proceed.

CHAIRMAN M. S. REID: Mr. President, members and guests:

The report of Committee 22—Economics of Railway Labor, appears in Bulletin 589, pages 257–271 incl. The reports on the committee's six assignments have been condensed to conserve time.

Assignment 1—Revision of Manual

Chairman Reid: There will be no report on Assignment 1. No revision was deemed necessary. I should, however, like to recognize Professor W. W. Hay, of the University of Illinois, chairman of the subcommittee. Thank you, Professor Hay.

Assignment 2—Analysis of Operations of Railways That Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work

Chairman Reid: The report on Assignment 2 will be given by Subcommittee Chairman N. H. Williams, bridge and building master—system, Delaware & Hudson Railroad.

N. H. Williams: This report, submitted as information, describes the production-line method used in the dual laying of continuous welded rail on the Baltimore & Ohio Railroad. It is the 23rd report on "Analysis of Operations of Railways that Have Substantially Reduced the Cost of Labor Required in Maintenance of Way Work," which subject has been reassigned annually since 1935. The report is based on a field inspection trip made by Committee 22 on July 10, 1964, on the single-track main line of the B&O south of Frederick, Md.

The complete report begins on page 259 of Bulletin 589, December 1964. It describes the close attention to details, the intensive planning, and coordinated supervision necessary to justify this type of rail laying.

The committee was impressed with the high morale of the organization; from conversations with personnel on the job, it is evident that all concerned were very proud of the dual rail laying gang and its capabilities.

Each member of this subcommittee is thanked for his contribution to the report.

Assignment 3—Economics of Labor in the Laying of Continuous Welded Rail, Collaborating with the Special Committee on Continuous Welded Rail

Chairman Reid: The report on this assignment will be given by J. R. Miller, assistant to chief engineer, Illinois Central Railroad.

J. R. Miller: Mr. President, member and guests:

The report on Assignment 3 appears in Bulletin 589, December 1964.

It was compiled from the 14 replies received to a questionnaire sent to 40 railroads. The roads replying represent a total annual welded rail program of about 700 miles.

It was concluded that if any appreciable economies are to be effected, more on-track time must be available and new and more efficient laying equipment developed.

Assignment 4—Labor Economies of Track and Turnout Construction or Relocation by the Panel Method versus Conventional Methods for Main and Yard Tracks

Chairman Reid: J. T. Sullivan, division engineer, New York Central System, is chairman of this subcommittee but is not present today. The study of this subject is in progress and a report will be made next year.

Assignment 5—Labor Economies to be Derived from Modern Bridge Maintenance Organization Using the Latest Equipment.

Chairman Reid: F. H. McGuigan III, construction engineer, Missouri Pacific Railroad, is chairman of this subcommittee, and I should like to have him stand and be recognized. The study of this subject is in progress and a report will be made next year.

Assignment 6—Economics of Labor in Tie Renewals—Cutting Ties Versus Removing Whole Ties

Chairman Reid: The report will be given by Subcommittee Chairman G. E. Warfel, district engineer, St. Louis–San Francisco Railway.

G. E. Warfel: The report on Assignment 6 appears on pages 270–271 in Bulletin 589, December 1964.

Chairman Reid: Thank you, Mr. Warfel.

Are there any questions from the floor pertaining to these reports? If not, Mr. President, this completes the report of Committee 22.

[Vice President A. V. Johnston assumed the Chair.]

Vice President Johnston: Thank you, Mr. Reid, and the members of your committee for the valuable work you have all accomplished during the past year. Your committee has played an important role in revolutionizing maintenance of way and structures work on the railroads, and I am sure it will make many further valuable contributions in the future.

Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Waterways and Harbors

[For report, see Bulletin 588, pages 167–176]

Vice President Johnston: The last report of this morning's session will be that of Committee 25—Waterways and Harbors, the chairman of which is F. J. Olsen, until recently resident engineer, Baltimore & Ohio Chicago Terminal Railroad, now engineer, Thomas McQueen Company, Forest Park, Ill. Will Mr. Olsen and the members of Committee 25 please come to the platform, with the subcommittee chairmen who will be making reports taking seats nearest the podium.

Mr. Olsen, you may proceed.

Chairman F. J. Olsen: Mr. Vice President, members of the Association and guests:

The complete report of Committee 25 appears in Bulletin 588, November 1964, pages 167–176, incl. Reports will be made on four of the six assignments. Three of these reports are progress reports and one is a final report.

Assignment 3—Bibliography Relating to Benefits and Costs of Inland Waterway Projects Involving Navigation

Chairman Olsen: This subcommittee has been annotating references relating to benefits and costs of inland waterway projects. Eight such annotated references are presented in Bulletin 588 beginning on page 168. M. A. Michel, retired special representative—staff, Pittsburgh & Lake Erie Railroad, was chairman of this subcommittee. The new chairman is G. W. Becker, special engineer, drainage, Chicago, Rock Island & Pacific Railroad, with headquarters at Chicago. Mr. Becker, will you please rise? Thank you.

Assignment 4—The Use of Hydraulic Models for the Study and Resolution of Waterway Problems

Chairman Olsen: The final report on Assignment 4 begins on page 170 of Bulletin 588. The report was prepared by J. F. Piper, assistant chief engineer—construction, Pennsylvania Railroad, Philadelphia. Mr. Piper, will you please stand? Thank you.

Assignment 6—Planning, Construction and Maintenance of Rail–Water Transfer Facilities

CHAIRMAN OLSEN: The report on Assignment 6 will be given by J. C. Fenno, assistant division engineer, Milwaukee Road, Milwaukee, Wis., chairman of the subcommittee. Mr. Fenno.

J. C. FENNO: As part of the "Planning" stage of this assignment, your committee presents as information a report entitled "Location Considerations," which may be found in Bulletin 588, November 1964, pages 171 to 176.

The report discusses the various factors involved in the location of a land–water terminal, including geological features, effects of earthquakes and explosions, currents, tides and winds for both ocean sites and inland locations. It includes a brief discussion of the site location as related to the function of the terminal, with emphasis on location requirements for trackage, other land traffic and water traffic. The report also furnishes a brief bibliography on the subject.

Your committee is now making a study of various types of facilities and expects to report on this phase next year. We have but scratched the surface of this assignment, and recommend that the subject be continued.

Assignment 7—Relative Merits and Economics of Construction Materials Used in Waterfront Facilities

CHAIRMAN OLSEN: The report on Assignment 7 will be given by G. R. Collier, chief engineer, Gulf, Colorado & Santa Fe Railway, and vice chairman of Committee 25, for Professor Shu-t'ien Li, South Dakota School of Mines and Technology, chairman of subcommittee 7, who is unable to be present at this time.

G. R. COLLIER: Mr. President and gentlemen:

Your committee reports progress in the course of documenting information pertaining to relative merits and economics of construction materials used in waterfront facilities, including:

(a) Prestressed concrete piles of square, hexagonal, octagonal, and circular cross sections.

(b) Prestressed cylindrical concrete piles, as these piles have higher strength to resist direct and bending loads and are less liable to cracking.

(c) Expansive-cement concrete for making reinforced or prestressed concrete piles, wharf decks, transit-shed roofs and wall panels, as expansive cement can produce crack-proof and shrinkage-compensating concretes, chemical prestressing, waterproofing, etc., if such concretes are properly controlled and restrained.

(d) Side-by-side comparative performance records for untreated greenheart piles versus treated piles of southern pine and Douglas fir.

Subcommittee 7, besides continuing its studies in (a), (b), and (c), submits as information the technical report on "Expansive Cements and Concretes," authored by Dr. Shu-t'ien Li, as published in AREA Bulletin 588, Proceedings, Vol. 66, November 1954, pages 177–182.

CHAIRMAN OLSEN: Committee 25 lost one of its subcommittee chairmen to the "Old Rail Club." He is M. A. Michel, who retired as special representative—staff, Pittsburgh & Lake Erie Railroad, November 30, 1964. Mike, as we all called him, will be missed. The entire committee wishes him a healthy, joyous and long retirement.

Mr. Vice President, that completes our report, but before I leave the podium I want to publicly thank all the members of Committee 25, and particularly the vice chairman and subcommittee chairmen, for their sincere cooperation and support during my three years as chairman. It has been a pleasure and a rewarding experience to have worked with them.

My last duty as chairman of this committee is a pleasant one. I would now like to introduce the incoming vice chairman and chairman of Committee 25 for the next three years.

The vice chairman is J. C. Fenno, assistant division engineer, Milwaukee Road, with headquarters at Milwaukee, Wis. Mr. Fenno, will you please rise? Thank you.

The new chairman is G. R. Collier, chief engineer, Gulf, Colorado & Santa Fe Railway, with headquarters in Galveston, Tex. Mr. Collier.

Mr. Vice President, this concludes our report. Thank you for your attention.

Vice President Johnston: Thank you, Mr. Olsen and the members of your committee, for the fine work you have done this year on this important subject.

Mr. Olsen, we appreciate the able and dedicated leadership which you have given to Committee 25 for the past three years. As you are relieved of your responsibilities as chairman, we are pleased to welcome as your successor, Mr. Collier, and as the new vice chairman of your committee, Mr. Fenno. We are satisfied from their past performance that under their direction the good work of your committee will continue.

Mr. Collier, as a symbol of your new authority, and to assist you in conducting the meetings of your committee, I would like to present you with this chairman's gavel. The inscription reads: "G R. Collier, Chairman, AREA Committee 25, 1965–1967."

Mr. Olsen, your committee is now excused with the thanks of the Association. [Applause]

Vice President Johnston [continuing]: Gentlemen, this completes the morning session. I suggest that the members of the seven committees that are holding luncheons this noon proceed promptly to their luncheon, looking forward to reconvening the afternoon session here promptly at 1:30 pm. We have an interesting program for this afternoon which will begin with the report of Committee 14—Yards and Terminals, and an important address by R. S. Reebie, assistant vice president, Market Planning and Research, New York Central System, on "Engineering Efficient Transfer Terminals, the Keystones of Successful Rail–Highway Transportation." I hope you will all be here to hear Mr. Reebie.

The meeting is now recessed.

[The meeting recessed at 12 noon.]

Afternoon Session, March 23, 1965

[The meeting reconvened at 1:30 pm, President Burris presiding.]

President Burris: Gentlemen, we will begin the afternoon session promptly because we do not wish to extend the meeting too long this afternoon. I should like to have as many of you see the show upstairs as possible. We have an interesting program this afternoon, including the reports of five committees and three special features.

Discussion on Yards and Terminals

[For report, see Bulletin 588, pages 127–142]

President Burris [continuing]: Our first report of this session will be that of Committee 14—Yards and Terminals, the chairman of which is D. C. Hastings, assistant vice president—operations, Atlantic Coast Line Railroad.

Since Mr. Hastings and his Committee are already in place on the platform, I will turn the microphone over to him with this added remark: If you desire to comment on, or ask questions in connection with, any portion of a committee's presentation, please stand, address the Chair, state your name and railroad or other affiliation, and then proceed.

Mr. Hastings, you may begin your report.

Chairman D. C. Hastings: Mr. President, members of the Association and guests:

For those of you who did not have the opportunity during luncheon to either hear a radio or watch television, Committee 14—Yards and Terminals, would like to report to the Association that the Gemini mission made a safe landing at the designated terminal in the Atlantic Ocean. At 2:18 pm Eastern Standard Time, the pick-up ship was seven miles away and a helicopter was hovering over the capsule. [Applause]

During the year 1964 Committee 14 was actively engaged in the study of seven very important and timely subjects. Reports on three of these have been printed in Bulletin 588, beginning on page 127. The chairmen of the subcommittees have worked faithfully throughout the year in order to be able to present these reports to the Association, and I am happy that they are here to make their presentations.

Assignment 1—Revision of Manual

Chairman Hastings: There are no recommendations for revisions to Chapter 14 of the Manual this year. The chairman of this subcommittee, F. E. Austerman, chief engineer, Chicago Union Station Company, is actively engaged in keeping Chapter 14 up to date. He will continue as chairman of this subcommittee during 1965, concentrating on that portion of Chapter 14 dealing with passenger terminals. At this time I should like to recognize the outstanding job he has done for Committee 14 and the Association as chairman of this very important subcommittee. Mr. Austerman.

Assignment 2—Classification Yards

Chairman Hastings: Committee 14 is still vitally interested in the subject of "Rollability of Freight Cars," and is currently collaborating with the special committee that has been appointed by the AAR to study this subject.

The subcommittee is also studying the effect of long freight cars on yard and terminal design. Considerable work has been done on this subject, taking into consideration the limits of both horizontal and vertical curves as well as the effect of such freight cars in the operation of hump yards. The study is quite complicated, and is one that must be continued for another year. A final report will be submitted in 1966 as information. The work of this subcommittee is being directed by Mike Rougas, engineer of track, Bessemer & Lake Erie Railroad Company, Greenville, Pa. Mr. Rougas will continue as chairman of this subcommittee during 1965.

Assignment 3—Scales Used in Railway Service

Chairman Hastings: The Scale Subcommittee has accomplished a considerable amount of work during 1964, and I should like to ask W. P. Buchanan, supervisor of scale inspectors—engineer of tests, Pennsylvania Railroad, Altoona, Pa., to present to the Association the work of his subcommittee Mr. Buchanan.

W. P. Buchanan: Mr. President and members: During the past year our committee has worked on the following subjects:

1. Specifications governing the manufacture and installation of electronic track scales, prepared by J. L. Dahlrot, general scale inspector, Louisville & Nashville Railroad. A progress report on this matter is submitted as information with the recommendation that the subject be continued and that the material be submitted for approval and publication in the Manual in 1966. This report can be found in Bulletin 588, November 1964, page 129.

2. Specifications governing the manufacture and installation of automatic indicating and recording elements for large-capacity scales, prepared by I. M. Hawver, chief scale inspector, Atchison, Topeka & Santa Fe Railway. A progress report on this matter is submitted as information with the recommendation that the subject be continued and that the material be submitted for approval and publication in the Manual in 1966. This report can be found in Bulletin 588, November 1964, page 137.

3. Study of accuracies obtained in motion weighing. Considerable data were accumulated during 1964 which are currently being tabulated and studied. Further tests of the various methods of motion weighing are expected to continue in 1965, the results of which, with data already accumulated, will be reported in 1966.

4. Coupled in Motion Weighing. Tests have been conducted on scales installed by the Reading Company at Reading, Pa., and by the Western Maryland Railway at Baltimore, Md., by a joint AAR—AREA committee, and data from these tests have been tabulated. The committee plans to conduct additional tests at other locations in 1965 for an information report in 1966.

5. Our committee has recently completed a study requested by the Interstate Commerce Commission through the AAR for a set of National Uniform Rules to cover the weighing of long-wheel-base cars on scales of insufficient length in accommodate the entire car for one-draft weighing. A report on this subject has been completed and forwarded to the AAR.

6. A special AAR Committee consisting of several members of this committee, Committee 16 and transportation officers of several Member Roads are studying "The Economic Justification of Weigh-in-Motion Scales." A final report on this matter is expected this year.

Assignment 4—Spot Repair Facilities for Diesel Locomotives

Chairman Hastings: After two years of work the subcommittee was unable to obtain enough information of importance to present a report to the Association as information, and therefore the subject will be dropped.

Assignment 5—Integral Trains—Their Effect on Existing Yards and Design of New Yards

Chairman Hastings: Considerable work was completed on the subject during 1964 which supplemented the report that was submitted to the Association as information last year. The subcommittee plans to continue its study of this most timely subject, and will submit another report as information in 1966.

The assignment for the past two years has been under the capable leadership of F. S. King, superintendent, Pennsylvania Railroad, Harrisburg, Pa., and in 1965 will be handled by G. H. Chabot, assistant to chief engineer—system, Chesapeake & Ohio Railway, Huntington, W. Va.

Assignment 6—Present Trends in Modernization of Yards and Terminals in Foreign Countries

CHAIRMAN HASTINGS: The report on Assignment 6 will be presented by the subcommittee chairman, G. H. Chabot, assistant to chief engineer—system, Chesapeake & Ohio Railway. Mr. Chabot.

G. H. CHABOT: Mr. President, members, guests:

Last year your committee submitted as information a report on present trends in the modernization of yards and terminals in certain foreign countries, namely Great Britain, France, Algeria and India.

To supplement this information, this year's report, which can be found on pages 140 to 142, incl., of Bulletin 588, describes in condensed form the most important yard and terminal developments and modernizations in Belgium, Czechoslovakia, England, France, Spain and Switzerland.

Your committee submits this report as information with the recommendation that the subject be discontinued.

Assignment 7—Factors to be Considered in Determining the Relative Merits of Various Types of Yards

CHAIRMAN HASTINGS: The subcommittee has completed considerable work on this subject and plans to continue its study, presenting a report as information in 1966. The work of this subcommittee is being handled by B. E. Buterbaugh, special engineer, St. Louis–San Francisco Railway, Springfield, Mo.

CHAIRMAN HASTINGS: Committee 14 has prepared a special feature which I am sure will be of interest to the Association. I shall ask M. H. Aldrich, senior civil engineer, New York Central System, New York, if he will please introduce this special feature for us. Mr. Aldrich.

M. H. ALDRICH: Committee 14 takes a great deal of pleasure in bringing to you as its special feature a presentation on the timely and pertinent subject of engineering of efficient transfer terminals. Our speaker is a man who is exceptionally well qualified for this assignment, and he has graciously consented to come here today to address us. His education includes degrees from Massachusetts Institute of Technology in Aeronautical Engineering and in Business and Engineering Administration. He formerly specialized in the fields of business logistics and rail and truck transportation with a management consultant firm. His background also includes experience in the fields of warehousing, moving, air transportation, and the administration of research.

In 1960 our speaker joined the New York Central to establish the Department of Industry Planning, and two years later his responsibilities were expanded to include Market Research, Equipment Planning and Service Planning.

It gives me great pleasure to be privileged to introduce to you Robert S. Reebie, vice president, planning and development, New York Central System, who will speak to us on the subject "Engineering Efficient Transfer Terminals, the Keystones of Successful Rail–Highway Transportation."

Engineering Efficient Transfer Terminals—the Keystones of Successful Rail–Highway Transportation

By ROBERT S. REEBIE
Vice President—Planning and Development, New York Central System

Thank you Mr. Hastings, Mr. Aldrich, and good afternoon.

I believe that my being here today was occasioned by some remarks I made last spring at the ASCE meeting in Cincinnati. At that meeting capable engineering planners discussed terminal facilities for airports, rail transit, and highway commutation. Detailed city plans were being made for centralized locations, highway access adequate for peak hour rushes, parking space, etc. I would like here today to repeat my suggestion that the public interest might also require city planning support for rail–highway transfer terminals of the scope of the Port of New York Authority's water–highway–rail container transfer facilities prepared for private carrier use. Certainly this would ease the problem we frequently encounter as each suburban community attempts to deny us location of a terminal in their particular community even though they acknowledge the benefits of combining economic rail line haul with the flexibility of truck delivery which requires that trucks fan out from an intermode terminal with loads of automobiles, packages, and bulk freight. As we handle more and more freight in this way, the importance of new terminal thinking on a broad scope becomes clearly evident.

In a similar way, we need more analytical dialogue to develop among shipper and transportation interests a consensus concerning the most advantageous container systems. Such a consensus, based on economic analysis, appears to be a necessary prelude to the widespread adoption of a common system which will allow the maximum interchange between the various modes as well as among the railroads that now use different systems. Since you are the engineers of the railroad industry, perhaps it is appropriate that I challenge you with the two tasks of obtaining agreement on the best rail–highway container system and of designing efficient rail–highway terminals.

Now as we discuss containers, we should recognize that there is a new climate in our economy. Today managements throughout the economy are shedding the same kind of attention and techniques that have been shed in the past on finance, production, and sales on an area that we might call "physical distribution" or "business logistics." This commercial interest is based on recognition of the fact that business logistics serves as a basic footing of profit and return on investment. Further, there is recognition of the need for the systems approach to integrate the wide number of independent but interrelated functions. Managements are also recognizing that business logistics are a severe area of marketing competition wherein they must strive to achieve their optimum service-cost compromise.

But the systems logistics approach is just as important to a nation and its broader public interest as it is to commercial companies. Obviously the optimum utilization of our resources in such a major area of our economy as logistics is necessary if we are to achieve better living through lower cost, a favorable international economic competitive position, a sound defense posture, and efficient operation of public agencies such as the Post Office.

If we consider the optimum use of logistics resources we find that research is needed to evaluate alternative concepts in terms of their economics and practicalities, their commercial relationships, and only later should we engage in the final phase of hardware design and evaluation. It is also important that each mode play its most economic part, both wherever it can handle transportation as a one-mode move and where it relates to other modes in intermodal transport. Recent presentations by Department of Commerce officials indicate that the Federal Government intends to assume considerable initiative in sponsoring through-movement logistics with economic combinations of services of various modes and carriers.

As we consider the optimum use of logistics resources, we would do well to stress the need to rely on free enterprise to achieve the ultimate potential that is inherent in each mode. Here it is important that we have a less restrictive regulatory climate if we are to achieve the proper balance of coordination, integration and competition. It is also essential to achieve sound, economic pricing which reflects the cost superiorities of various concepts and thus influences the most economic allocation of traffic rather than that which is most political.

Perhaps my final comment today on the optimum use of logistics resources should stress the fact that we must anticipate constant change as new technology makes possible improved concepts. The important factor here is to make sure that we utilize the research mentioned above to evaluate the concepts before they are widely progressed with investment in equipment, facilities, and organization.

Value of Systems Analysis

In the evaluation of concepts it is helpful to recall comments which I believe were made during World War II by Vannevar Bush when he headed the Office of Scientific Research and Development. Dr. Bush pointed out that there are a number of steps involved in the progression of any complicated equipment system from the idea, paper, and pencil stage through the study phase, the test model phase, the prototype phase, etc., up through the production model. Each succeeding step involves more and more hardware and, therefore, cost. Thus the development of a new idea, or the rejection of one which proves unsound, is more costly in the later hardware phases than in the early idea, paper, and pencil phase. Obviously there is an advantage to going down the blind alleys, which are always experienced in innovation, as much as possible in the early idea, paper, and pencil stage rather than in the more costly succeeding stages. All too often transportation has jumped with major investment into production models before they had been fully evaluated. For example, while practical progress was made through the use of concepts like trailer piggyback and the military Conex box, economic research would have shown that superior concepts were available. Economic research of containers will be the subject of some of our discussion today.

Highway Carriers Reducing Costs

In any discussion of the climate in our economy, we must include comments on the progress being made by highway carriers to improve their costs and service. They are pushing for the larger loads, and they are being assisted in their efforts by public agencies sponsoring improved highways and higher vehicle size and weight limits. Finally, the truckers are pushing the use of unit loads, internal containers, 20-ft containers, and sound pricing to resolve their interface problems with shippers. Certainly if the railroads are to maximize their market penetration, profits, and return on investment, they must similarly improve their costs and provide the services which are required by our low-inventory, short-order, through-logistics economy.

TERMINALS OF VITAL IMPORTANCE—SYSTEMS ANALYSIS REQUIRED FOR EVALUATION OF CONCEPTS

Now as we progress in our discussion of containers it is important to recognize that the terminal is the "nut" of the transportation business. And it is this "nut" which we must crack if we are to achieve a high level of customer service and carrier profits. To evaluate intermodal transfer terminal concepts we need to use systems analysis for the analysis of alternative logistics patterns and look at both the economics and practicalities of the total overall service-cost relationship. The systems approach is necessary because we find a variation of solution depending on the characteristics of various commodities and the relative importance of primary rail line haul, secondary highway line haul, terminal handling costs, and customer costs. To give you an example, the cost of handling package freight is very high. Therefore, it appears a good bargain to change from transporting package freight in box cars and requiring piece handling into local delivery trucks to the use of demountable bodies involving a slightly higher primary rail line haul cost and a slightly higher secondary highway cost. The result is to achieve a net savings in the combination of rail and highway through the transfer of a full container of packages rather than the individual packages.

On the other hand, the reverse was true with automobiles. You will recall that when the railroads first began to return the automobile traffic from the highway they used a container, a trailer if you will, for the transfer of a load of automobiles onto the rail car at the origin and off of the rail car at the destination. However, the piece handling of automobiles is relatively inexpensive. Therefore, it has proven more economic to run up the origin terminal costs a little bit as we piece-handle automobiles into a high-capacity rail car and to run up the destination terminal costs somewhat as we piece-handle the automobiles out of the rail car and into the most efficient trailer for the states in which delivery is to be made, in order to get much greater savings in the primary rail line haul and the secondary highway line haul.

In a similar way, we find in the handling of liquid and dry bulk, it is generally more economic to transfer the commodities than a container of the commodity. Some of you may be aware of the New York Central's development of the Flexi-Flo cars in order to utilize differential pneumatic pressure in the transfer between rail and highway of dry bulk solids such as cement, grain, food, sugar, phosphates, etc.

INTERNAL CONTAINERS AND UNIT LOADS

Today we shall restrict our discussion mostly to package freight and the use of containers, which frequently prove to be the most efficient method of amalgamating the interests of carriers and shippers. Perhaps we should not progress to the major subject of external van containers without a few comments on the frequent applicability and advantages of internal containers for small shipments and unit loads of various kinds. Certainly these smaller units bring considerable advantage in the areas of pick-up and delivery, dock handling, intermodal transfer, and clerical control. Further use of the unit load is being made to eliminate break-bulk handling by shippers who build into the original unit load the proportional mix of different commodity items required by the average customer.

A review of small containers might start with the original Railway Express Agency 5-ft external container. While I have not been personally involved in a great deal of study of this size container, my understanding of the interrelationship of the factors involved leads me to believe that this small external container will have only limited application. The needs of smaller shipments can more properly be met with internal containers which are now being effectively utilized by the Railway Express Agency. In some instances the non-returnable internal container has its place.

Internal containers are used by the airlines to consolidate shipments on receipt at their dock for efficient and rapid origin loading, intermediate break-bulk, and destination unloading of the aircraft. These large units are easily handled into and out of the aircraft with specialized equipment and the provision of facilities for moving the unit loads inside the airplane. Use of these containers has not only reduced the cost, loss, and damage of terminal handling, but also has considerably reduced the elapsed time in terminals with coincident benefits for shipment service and utilization of the high investment in aircraft equipment. It is primarily through methods such as these that the airline industry is hoping to get its costs down in the area of 8–12 cents per ton mile.

While the use of these containers has proven helpful to the aircraft industry it is also proving exceptionally helpful to the trucking industry and to the railroads; freight can be sorted by destination with very little additional labor content at the same time it is picked up. Considerable savings are then available as the pick-up truck is unloaded at the origin dock and the freight moved to the outbound road haul unit. This concept has been further developed with the use of expandable, collapsible internal containers of low cost which can be loaded into the line haul unit without important loss of cube, additions in weight, or additional expense. This concept has now been progressed to where its manufacture is relatively inexpensive through the use of slats instead of plastic siding and more efficient crosstie techniques.

Any discussion of internal containers should not bypass the unit load on various kinds of pallets and skids. Last of all I should mention that considerable advance can be expected in the handling of internal containers for loading aboard air, highway, rail, and water vehicles through the use of pneumatic flotation devices which are now progressing to the point where they are both feasible and economic because they require only low volumes of low pressure air, inexpensive equipment, and little or no modification of dock or vehicle floor construction.

ANALYSIS OF VAN CONTAINER ECONOMICS

Now we should progress to discussion of our major topic, the van-type external container. Advantages in use of these containers runs the full gamut of improved pick-up and delivery involving reduced dock investment and handling costs for shippers, carriers, and consignees, and the advantage of combining multiple units for local pick-up and delivery and short highway hauls. These containers also offer the well known advantages of improvements in loss and damage, packaging, environmental control, and storage. Our discussion, however, will also highlight some major but less well known advantages in reduction of line haul costs, both for primary rail line haul and for secondary highway haul involving short distances and low density transportation areas.

Comparison of Dock Concepts

As we start to discuss the van-type container we should first review the dock costs involved in terminal operations of the small shipment business. The basic lessons learned in this analysis are equally applicable to Post Office, Express, Forwarder, and a whole host of distribution operations. Because of the difficulty of moving individual units into and out of the rail freight house, without disrupting work on other units, the house is only switched a few times each day and the facility must accommodate empty or loaded units which are not being worked at any given time. This requires a considerable increase in the amount of dock facing and distance of dock travel. Thus the rail box car freight house can be shown to require upwards of 50 percent additional investment and to require 25 percent greater handling cost as freight is processed across the dock. Further, since the trucker is able to pick up or deliver approximately 25 percent of his small shipment business of the 5,000-, 7,000-, and 10,000-lb variety with the line haul unit, he is able to bypass the origin or destination dock handling cost to this amount. Thus if the cost to process the freight across a truck dock were 20 cents per hundredweight and 25 percent of this cost was normally avoided, it could be said that the trucker's dock cost would average 15 cents per hundredweight while the railroad dock cost would average 25 cents per hundredweight. Finally, we envision a greater capability for bypassing the truck dock as the use of 20-ft containers increases.

Thus it becomes obvious that for a great number of transportation needs the freight should be moved to and from the dock and the local area via city pick-up and delivery units and the freight moved to and from the dock and the line haul function with containers. It becomes obvious that it is important that dock facilities of this kind and the railroad container transfer or piggyback yards should be located adjacent to one another and as close to the economic center of pick-up and delivery of the terminal area as possible.

Flexi-Van Proves Advantages of Containers

While this concept can be utilized with piggyback trailers as the line haul container, it should be pointed out that containers offer considerable advantage in enabling shippers to gradually move from their present carload concepts and facilities to rail-highway concepts. For instance, the New York Central's Flexi-Van concept has been modified so that the containers have side doors and can be loaded inside a traditional Post Office baggage car facility while the containers sit on the rail cars. On the New York Central, the Post Office Department is loading our Flexi-Vans in such eastern baggage car terminals as New York and Boston, while at Chicago the container is taken off of the car and moved directly to the outlying Post Office facility, with considerable increase in speed and reduction in cost over the former method of handling the mail out of a baggage car, across a dock, and then into a local delivery truck for the same local transportation.

Now, the New York Central has been progressing these concepts with its COFC container system which was developed by the Strick Trailer Company and bears the trade name of the Central's rail–highway service, Flexi-Van. We wish to point out that the Central is well satisfied with this concept which has proven greatly superior to piggyback. There can be little question but that this is the largest workable container system available today and probably will continue to be so for some time in the future. We fully intend to make continued use of our investment in this concept and can encourage shippers and other carriers of various modes who wish to adopt this concept to do so. The Central itself plans to use its present equipment for decades even if some of the newer concepts do indeed prove to meet the expectations of analysis, and we are still expanding our Flexi-Van fleet for both domestic and export services.

As we now progress to discussion of some newer container concepts let us point out that the Central does not believe that its economic analysis of future concepts is the final answer. We encourage participation in a competition of concept development by all interested parties, with the hope that evaluation of the various concepts according to sound economic principles will demonstrate the direction in which our mutual hardware design and investment should progress. Finally, the Central probably cannot afford to move independently into any new area until its advantages have been thoroughly documented and a widespread consensus supports its adoption by other carriers and modes.

Future Container Transfer Concepts

With this preface let us look at some of the concepts which we think bear merit. First, we should like to look at a terminal-handling piece of equipment called a straddle or van carrier. These units can pick up a van, lift it high enough to leapfrog over other vans still remaining on adjacent rail cars, and carry it at speeds of 20 mph or so to a location where it can be placed for unloading at a truck-style dock without the container ever requiring its own chassis or wheels. In a similar manner the container could be placed on a chassis or bogey for handling over the highway within the terminal city or surrounding area. This concept is not a blue-sky figment of our imagination but a workable concept which has been in operation at various port facilities for upwards of five years. Economic analysis shows it to be the most efficient method of taking a container from a train to a dock or highway chassis, far superior to breaking or making trains with switch engines or various forms of piggyback loading and unloading. It is possible to envision future terminals as a complex of truck-style docks adjacent to the container transfer yards.

Mobile gantry cranes are being mounted on either rubber tires or steel rail wheels. These units have their greatest applicability where trailers must be lifted sideways off of a rail car or for use at intermediate terminals. The train is pulled off of the main line into a terminal where inbound containers are taken off, outbound containers are placed on, in a matter of five minutes to half a hour, and the train progresses en route without recourse to a switch engine. This concept is obviously far superior to the present container and piggyback concepts which set out inbound loaded cars at intermediate spots for subsequent unloading and which pick up outbound cars that have already been loaded. It is our hope to come to a concept where we can sell the seat over twice, as they discuss the matter in the passenger business. However, much remains to be done in improving the cost and reliability of overhead transfer equipment.

Shuttle Trains for Quality Service, Equipment Utilization, Low Cost

Nevertheless, we have progressed quite well in achieving improved service and equipment turnaround through use of all-container trains. These were initiated by the Central with its Super-Van trains, and are achieving utilization approximately of 14 revenue trailer loads per month with an average haul of over 800 miles per car. Analysis has shown it is economic to spend money to break up the train into smaller segments in order to reduce terminal travel at the origin and destination, but that it is more economic to work the train in its full length at intermediate stops. In this way, operating between a limited number of terminals, we can achieve costs considerably below those of the highway for similar line haul operations. This then enables us to achieve the best balance of economic rail for line haul and flexible truck for the dock handling and pick-up and delivery operations.

Economics of Blending High- and Low-Density Shipments

While the economics utilized in the above analyses were based upon present Flexi-Van container costs, which are lower than comparable piggyback costs, we should like now to discuss a newer concept. Whereas the letters TOFC have been used to describe piggyback and the letters COFC have been utilized to describe container-on-frame-car, I should like to utilize the letters SCOFC to discuss the newer concept of stacking-container-on-frame-car. This newer concept utilizes containers to bring to the railroads the full advantages of the optimum blending of weight and cube to utilize the full capacity of advanced rail car concepts. This blending of high-density and low-density freight to utilize the full weight and cube capacity of vehicles has already been played to a fare-thee-well for many years by both the deep water and the highway industries.

Rather than carrying a maximum cube load of low-density items and a maximum weight load of high-density items from town A to town B, a trucker will endeavor to carry a mixed load of both commodities in each trailer. Under the former circumstance he might have in one trailer a load of 15,000 lb and 2,400 cu ft and in the second trailer a load of 48,000 lb and 1,000 cu ft. With a blend of the two commodities it is possible to achieve a load of 35,000 lb and 2,400 cu ft in each trailer. Thus the capacity utilization of the two trailers has been raised from 3,400 cu ft to 4,800 cu ft and from 63,000 lb to 70,000 lb merely by mixing the light and dense freight.

This concept is no different than the deep-water concept of endeavoring to leave port both full and down. The ship owners know that if they leave port low in the water, but with empty space inside, they are not utilizing a portion of their full economic capacity. Similarly, if they leave port with every cubic inch inside the vessel utilized, but high in the water, they are not fully utilizing another factor of their economic capacity. Without the use of economic capacity, ship owners recognize that their costs are higher, their rates are probably higher, and their profits and return on investment are probably lower than could otherwise be achieved.

Now let us turn our attention to the standard box car which can carry a very large cube or a very large weight, but experience shows that the box car seldom carries the best mix of both in order to fully utilize both its weight and cube capacity. Remember that the trucker went from his terminal to take a partial load from a heavy goods manufacturer, and then went to a second manufacturer to take on additional lightweight goods (or he may have topped off with lightweight goods previously brought back to his terminal dock.) With the inflexibilities of rail switching it is difficult to envision this kind of operation simultaneous with the achevement of a high level of service and a low level of cost.

Maximizing Utilization of Rail Car Cube and Weight Capacity

If we can turn our attention to TOFC or COFC, we find that in each case we are wasting a considerable amount of cube either below the trailer or above the container. Note should be made of the value of utilization of this cube to the railroads as exemplified in the transportation of automobiles where attempts were made to utilize fully the cube that lay between the top of the rail chassis and beneath the overhead clearance. This demonstration of the value of cube indicates that, other things being equal, the railroad with the better clearances may ultimately be the low-cost producer.

Let us, therefore, consider the SCOFC concept of stacking containers one on top of another in order to utilize the full cubic capacity available to us. Note should be made that the center of gravity will generally be lower than with piggyback or some of the high-cube hopper cars. Let us also then envision the use of shorter containers in the lower tier for the handling of dense commodities such as canned goods or drums of chemicals. Research has shown that many commodities run in a density of 48 lb per cu ft or higher and can fill a 20-ft van container to the maximum weight capacity allowed by highway law for any particular trailer unit. In fact, 20-ft containers with higher weights would probably have to be placed on stretch-frame trailers to meet the bridge laws. Prototype stretch-frame trailers have been designed which will accept maximum highway weight loads in any combinations of single 20-, 24-, 28-, or 30-ft containers or two 20-ft containers.

Analysis of Rail–Highway Container Economics

Let us now summarize the basic investment and cost factors which were highlighted in an economic analysis of each integrated rail–highway container system and their effects on the overall systems. They are listed below in descending order of importance:

1. Power—Less power investment and cost required with lighter and/or fewer cars and containers used under COFC and SCOFC. Power requirements are also reduced because of lower center of gravity needing fewer slow-down—speed-ups and because of lower wind resistance.
2. Containers and Undercarriages—Less container investment and cost under COFC and SCOFC because of savings in tax on containers, fewer undercarriages required on trips of two days or more. (The analysis considered an increase in undercarriages at 400 miles and a 3–5 ratio at 800 miles.) As the most numerous item in the system, containers should be designed with as little investment and cost as possible.
3. Rail Cars—The manner of terminal loading and unloading greatly affects the investment, weight, and cost of the cars. Cars for overhead loading of containers can be of a single frame design without end plates, side sills, or stanchions. Flexible use of 20-ft containers and SCOFC also allow fewer cars.
4. Terminals—Industrial engineering evaluations of the investment and cost in land, switches, track, paving, transfer equipment, and labor for each system have been included in the analysis. Note that concentrating investment for transfer capability in the overhead transfer equipment reduces the cost of this factor to an insignficant amount because of the low unit cost of high utilization and savings in other factors.
3. Flexibility—While not accounted for in the analysis, the advantage of selective side transfer is important to improvement in service elapsed time and reduction in switching. Similarly, fast side transfer will allow increased utilization of car equipment (and the servicing of more points) as the "seat" is sold twice at intermediate stops. Finally, containers with a floor at dock level when loaded on the car facilitate the change from box and baggage cars to rail–highway equipment.

Now let us see what advantages can be obtained through the COFC and SCOFC concepts. First, the railroads can achieve a fuller utilization of their cube and weight capacity for the line haul, and the line haul costs which were already considerably below those of highway have had their superiority increased considerably. Note should be made that car manufacturers must considerably improve the ride characteristics of their cars. Perhaps similar requirements for passenger trains will influence the design of improved trucks with improved tracking and thus lateral and vertical shock characteristics, maybe through air suspension.

Not only will these container concepts improve the line haul superiority of the railroads, they will also establish a terminal superiority over the highway carrier. Instead of incurring the high costs of topping off with the piece-handling of lightweight freight and incurring the wrath of shippers who object to the blending of their commodities with other shippers because of the damage and loss of time involved, the railroads will achieve their blending merely by the stacking of containers which requires a neglible amount of time in the loading or unloading cycles of the mobile gantrys and van carriers previously mentioned.

Highway Trains Service Off-Line Centers

Perhaps we should now indicate the advantages of the use of 20-ft containers in the secondary highway line haul. In the servicing of a satellite area approximately an hour away from a rail container transfer yard, it would be desirable to have the smaller units hauled to the destination city as economically as possible. Where the 20-footer represents either the maximum weight load allowable on the highway, or a day's work for a pick-up and delivery driver, it is an unnecessarily high cost for the driver to transport only one 20-footer behind him from the transfer terminal location to the destination city. Instead these units can be combined through the joining of trailers under the concepts which have been pursued both by the Strick Company and its parent, the Fruehauf organization, the use of double or triple bottoms, or finally the use of individually powered trains such as those which have been developed by Lloyd Wolf and the St. Louis Car Company. The individually powered unit concept is being progressed to where the body is a demountable 20-ft container and the chassis so designed that a maximum load of 40,000 lb can be carried. In addition, the truck can nose up to the dock and the driver have easy access to the freight through the front of the container with resulting savings in both elapsed time and labor content. With side doors, access can be had to all the freight so that the extra cost of route-stop-sequence loading can be eliminated.

Under this secondary highway–train concept, one driver might be quartered at the container transfer yard and work 10 hours a day. He would take a train of 20-ft units from the container transfer operation to a satellite city during the first hour of his day. At the destination city he would meet three other drivers who need not be waiting with unused tractors. All four men would then accomplish an 8-hour day's work. Finally at the end of the day the units would be reassembled and the original driver transport them back to the container transfer location.

CONTAINERS FACILITATE BUSINESS LOGISTICS

Now let's see how these equipment concepts fit into the systems approach to physical distribution or business logistics. In any map showing the distribution of major retail purchasing patterns in the United States, the concentration of market in the northeastern part of the country would be noticeable. If we then recognize the market pressures on manufacturers to supply their customers with smaller quantities in short order, the advantages of meeting these requirements with the minimum overall cost of centralized manufacture where the economies of scale are beneficial, and reductions in inventory, we are led to a study of a way to optimize the number of locations of warehouse facilities. In a typical domestic distribution system, orders are communicated by the customers to branch warehouses where the order processing is accomplished, the order picking is accomplished, and then delivery is made from stocks at the warehouse. This requires eventual reordering from the plant warehouse by the branch warehouse and the shipment of the reorder quantity out to the branch warehouse. This concept requires a large number of communications, handlings, organizations, and their resultant costs are high.

Today many firms are trying to move toward the newer concepts wherein they use the latest communications, data processing, warehousing, and transportation techniques to achieve the optimum service-cost compromise. Customer orders move under the most economic method, via sales offices or direct, to the centralized warehouse. Here the orders are now received in such volume that they can justify sophisticated computer order-processing hardware. Improved warehousing techniques are then used for order picking, and the goods are then moved from the central warehouse out to the origin container transfer yard for economic line haul movement to a destination container transfer yard for flexible highway delivery directly to the customer. Shippers who have followed in this approach have found that they eliminate the investment and overhead in branch warehouses, they reduce the inventory costs as inventories are recentralized (especially for slow-moving items), and they even reduce the clerical and control costs involved in communication and data processing.

Under these concepts the New York Central believes that economic, overnight distribution can eventually be provided to the major centers in the tremendous market area lying between southern Maine, Washington, D. C., Louisville, and Columbus from one central location in the Buffalo–Rochester area. Western manufacturers who find it necessary to warehouse close to their customers could serve the eastern half of this market from a warehouse in this location. Eastern manufacturers who also find it necessary to warehouse for rapid response of customer orders can store in the Buffalo–Rochester area for distribution to the western half of this market. Companies which find an economic supply of raw materials and labor for manufacture in the Buffalo area can distribute from a single plant warehouse which is always required to balance out the differences in level of supply and demand. Planning has already been progressed by the Buffalo City Fathers for their Thruway Industrial Park which can be utilized to develop an ideal Buffalo Distribution Center. Here two major railways could locate competing container transfer yards and access could be provided from these yards to manufacturing and distribution facilities with van carriers if the streets were planned sufficiently wide and without low overhanging wires. Access is available to the main superhighway network for ready movement to other locations of plants and distribution facilities in the surrounding geographic area.

Last year I attended a meeting where capable engineering city planners were concerned with airports, transit terminals, and port terminals. They were discussing centralized locations, highway access, parking space, materials handling, storage space, vehicle service, etc. I would like to repeat here today my suggestion that it is also in the public interest to encourage well-located, efficient, rail–highway terminals with the highway access necessary to fan out truck operations. The thinking should be on the same scope as that of airports or the Port of New York Authority's facility constructed for private carrier use.

Thus within the limits of time we have covered the contribution that containers can make to the maximum utilization of resources through the systems logistics concept, both for individual companies and for the national economy. [Applause]

Chairman Hastings: Thank you very much, Mr. Reebie, for that very interesting presentation.

Mr. President, I would like now to introduce to you the new chairman and vice chairman of Committee 14. The new chairman is H. J. McNally, chief engineer, New

York Improvements, Pennsylvania Railroad, and the new vice chairman is C. E. Stoecker, special engineer, Louisville & Nashville Railroad.

President Burris: Thank you, Mr. Hastings, and the members of your committee, for the continued high level of accomplishments on the assignments that have been given to you. The work of Committee 14 is most important. Thank you, Mr. Reebie, for your very interesting address on "Engineering Efficient Transfer Terminals." I am sure that those who heard you have obtained a new insight into this growing area of transportation. Your presence and your remarks have contributed greatly to the success of this Convention. Again, please accept our thanks.

Mr. Hastings, we appreciate the able and dedicated leadership that you have given to Committee 14 for the past three years. As you are relieved of your responsibilities as chairman, we are pleased to welcome as your successor Mr. McNally, and as the new vice chairman, Mr. Stoecker. We are satisfied from their past performance that under their direction the good work of your committee will continue.

Mr. McNally, as a symbol of your new authority, and to assist you in conducting the meetings of your committee, I would like to present you with this chairman's gavel. The inscription reads: "H. J. McNally, Chairman, AREA Committee 14, 1965–1967."

Mr. Hastings, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Water, Oil and Sanitation Services

[For report, see Bulletin 588, pages 99–126]

President Burris: The second report of this session will be presented by Committee 13—Water, Oil and Sanitation Services. The chairman of this committee is E. C. Harris, engineer of tests, Missouri Pacific Railroad, St. Louis, Mo. Will Mr. Harris and the members of his committee please come to the platform. The subcommittee chairmen making reports should take places closest to the podium.

Mr. Harris, you may proceed.

Chairman E. C. Harris: President Burris, members of the Association, ladies and gentlemen:

Committee 13—Water, Oil and Sanitation Services, is pleased to present its annual report, which appears in AREA Bulletin 588, November 1964, pages 99–126, incl.

During the past year four members, each of whom had served Committee 13 long and well, were taken from our midst. Let us pause in contemplation and pay tribute to the memory of:

Albert Willard Johnson, retired steam heat and water engineer, Atchison, Topeka & Santa Fe Railway.

Robert Cousins Bardwell, retired superintendent of water supply, Chesapeake & Ohio Railway, Member Emeritus of Committee 13 and Life Member of the American Railway Engineering Association.

Robert E. Coughlan, retired chief metallurgist and engineer of tests, Chicago & North Western Railroad.

Don C. Teal, retired superintendent water supply, Chesapeake & Ohio Railway, and my immediate predecessor as Chairman of Committee 13. Don, who died recently, on February 26, 1965, after a long illness, was a Life Member of AREA and Member Emeritus of Committee 13.

The pleasing personalities and outstanding services of these distinguished gentlemen will be long remembered. May they have crossed the bar to find eternal happiness and peace.

During the past year your Committee 13 had ten subjects assigned for research and study. Work on five assignments was completed, with reports being offered as Manual material. The remaining five subcommittees are offering progress reports. The chairmen of these subcommittees will now be called upon to give their reports.

Assignment 1—Revision of Manual

CHAIRMAN HARRIS: T. A. Tennyson, engineer of tests, St. Louis South Western Railway, chairman of this subcommittee, will now present his report.

T. A. TENNYSON: In conformity with the standing assignment your committee has continued to review Chapter 13 of the Manual to determine if revisions are needed to keep the information current and/or clear. The recommendations this year are all concerned with the section dealing with Diesel Locomotive Fuel and Water Service. They appear in detail on pages 102 through 104 of Bulletin 588 and have been approved by letter ballot. Therefore, this discussion will be limited to brief comments descriptive of the nature of the revisions.

Pages 13–9–1, 13–9–4, 13–9–6 and 13–9–8 have been revised so that the data thereon will be applicable not only to diesel fuel delivery by tank cars but also by highway truck transports, barges, private pipelines and common-carrier pipelines. This has been done to keep Section 9 of the Manual in line with current practice with regard to the receipt of diesel fuel.

Material on page 13–9–5 has been revised to include the larger capacity locomotive fuel tanks in conformity with current locomotive building practice.

Page 13–9–10 as revised now shows reference to the AAR Electrical Manual for details in connection with grounding.

Mr. President, I move that Manual revisions described on pages 102 through 104 of Bulletin 588, involving Manual pages 13–9–1, 13–9–4, 13–9–5, 13–9–6, 13–9–8 and 13–9–10, be approved.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 2—Prevention of Corrosion in Hot Water Systems

CHAIRMAN HARRIS: A final report has been prepared by this subcommittee for publication in the Manual. J. J. Dwyer, Chemical Engineer, Chesapeake & Ohio Railway—Baltimore & Ohio Railroad, chairman of subcommittee 2, will please present his report.

J. J. DWYER: Mr. President, Mr. Chairman, fellow members and guests:

The report to be discussed is "Corrosion Control in Hot Water Heating Systems," and is found on page 104 of AREA Bulletin 588 for November 1964. This is the third of a series by Subcommittee 2 on corrosion of steam and hot water systems, the preceding two already having become part of the AREA Manual.

This report concerns heating systems in which hot water is supplied from a boiler to a point of radiation and then returned to the boiler through a closed piping system, either by gravity or circulating pump, and with control of corrosion in such systems.

Such corrosion will generally originate from three sources, vis., (1) acid from carbon dioxide, (2) other dissolved gases, usually oxygen, and (3) galvanic action between dissimilar metals in the system. Prevention of air infiltration at pumps, fittings, valves, vents, etc., becomes of utmost importance, as well as restricting makeup water containing gases to a minimum. Oil, grease, pipe dope, and other foreign matter can contribute to corrosion potential by formation of anodic-cathodic areas under deposits.

Good chemical cleaning of new or overhauled systems is suggested first, and then consistent use of an approved chemical treatment designed for use in closed systems. The report is summarized by the following recommended measures which should be incorporated into the construction and maintenance of such a system:

1. Good mechanical design.
2. Good cleaning of new or overhauled systems.
3. Good maintenance.
4. Good chemical treatment.
5. Do not drain system unless absolutely required.
6. Do not permit entry of dissolved gases into system.

Mr. President, your committee feels that the foregoing information should be useful to railroad engineers as recommended practice. Therefore, I move that this report be adopted for inclusion in the Manual at the end of Part 4, Water Treatment, Chapter 13.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 3—Design, Construction and Operation of Railroad Sanitary and Servicing Facilities

CHAIRMAN HARRIS: C. F. Muelder, assistant to engineer of buildings, Chicago, Burlington & Quincy Railroad, chairman of subcommittee 3, will give the report of this subcommittee.

[Mr. Muelder then read the report on Assignment 3 as printed on pages 107 and 108 of Bulletin 588, November 1964.]

Assignment 4—Cathodic Protection of Pipelines and Steel Storage Tanks

CHAIRMAN HARRIS: This is another final report being offered as Manual material. During collaboration with AREA Committee 18 it was pointed out that some minor items of the subject matter of this report are also found in Section 9, Corrosion, of the AAR Electrical Manual of Standard and Recommended Practices. However, even though it has some minor duplications, our report is considered to be of sufficient importance for inclusion in the Manual as prepared.

W. F. Arksey, engineer water service and fuel facilities, Great Northern Railway, chairman of Subcommittee 4, will now give his report.

W. F. ARKSEY: Your committee has reviewed the reports on this subject published in 1957, 1959, 1961 and 1963 and recommends that the condensed material from these reports as published on pages 108 to 115 in Bulletin 588, Proceedings Vol. 66, November 1964, be adopted and published in the Manual.

Mr. President, I move that this information be made a part of the Manual of Recommended Practices.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 6—Railway Waste Disposal

CHAIRMAN HARRIS: The chairman of this standing subcommittee, F. O. Klemstine, supervisor water service, Pennsylvania Railroad, reports progress on their study of the problems involved in the handling of railway waste disposal, and will submit a report in 1966 covering methods of economically disposing of the refuse after such waste has been removed from the separating apparatus.

Assignment 7—Installation and Maintenance of Liquefied Petroleum Gas Facilities.

Chairman Harris: This is a final report for publication in the Manual. E. R. Schlaf, superintendent of fire prevention, Illinois Central Railroad, chairman of subcommittee 7, will now present his report to the Association.

E. R. Schlaf: Your subcommittee has reviewed the report on this subject published in the 1964 Proceedings, and recommends that the condensation as shown on pages 115 to 125 in Bulletin 588 be adopted and published in the Manual.

Mr. President, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 8—Methods of Controlling Spillage of Fuel Oil at Diesel Fueling and Unloading Stations

Chairman Harris: V. C. Barth, chief metallurgist and engineer of tests, Chicago & North Western Railway, chairman of the subcommittee, will now give his report.

[Mr. Barth then read the report on Assignment 8 as printed on page 125 of Bulletin 588, November 1964.]

Assignment 9—Disinfectants, Deodorants, Fumigants and Cleaning Materials

Chairman Harris: Tom Hendrix, engineer water service, Chesapeake & Ohio Railway, reports progress in the study of this complex subject, with special emphasis being given to the classification and use of cleaning materials. A final report is expected to be ready for presentation in 1966.

Assignment 10—Bacteria Growth in Diesel Fuel

Chairman Harris: W. C. Harsh, chief chemist, New York Central System, chairman of subcommittee 10, reports progress on their study and expects to present a complete report in 1966.

Assignment 12—Water for Battery Use

Chairman Harris: John Rodger, engineer of water service, Western Region, Norfolk & Western Railway, chairman of this subcommittee, has prepared a final report for publication in the Manual. The report covers the quality of water meeting minimum standards of acceptance for use in storage batteries, and stresses the adverse effects of using water containing iron and manganese salts.

Mr. President, I move that this report be accepted for publication in the Manual, Chapter 13.

[The motion was duly seconded, was put to a vote, and carried.]

Chairman Harris: My three enjoyable years as chairman of Committee 13 end at the closing of this convention. The willing and capable workers in this group who prepared our informative and interesting reports made my job as chairman a pleasure. I wish to thank all members of this distinguished committee and all the officers of AREA for their splendid cooperation and assistance.

I know that the gentleman who succeeds me as chairman, and the gentleman succeeding him as vice chairman, will receive the same help and guidance that I enjoyed during my tenure of office. Both of these new officers are long-time members of Committee 13 and both have a high capacity for committee work and are well qualified for these positions of honor.

The new chairman is engineer of tests of the St. Louis Southwestern Railway, Tom A. Tennyson. Mr. Tennyson, will you please stand and be recognized.

The new vice chairman is chemical engineer of the Chesapeake & Ohio Railway—Baltimore & Ohio Railroad, Jack J. Dwyer, Mr. Dwyer, will you please stand and be recognized.

Mr. President, this concludes the report of Committee 13.

President Burris: Mr. Harris, I want to thank you and your committee for a very worthwhile report.

When the steam locomotive began to go out of existence and the diesel began to take its place, one of the phases of our engineering work—water treatment for steam locomotives—faded out. But those people who were engaged in that part of railroad work soon found that there were many other things coming along that required their attention, and that fell right into their line of work. This committee has adapted itself extremely well in the new times.

Under your leadership in the past three years much has been accomplished, Mr. Harris. As you are relieved of your duties and responsibilities as chairman of Committee 13, we are pleased to welcome Mr. Tennyson as your successor and Mr. Dwyer as the new vice chairman of the committee. We are satisfied from their past performance that under their direction the good work of your committee will continue.

Mr. Tennyson, as a symbol of your authority, and to assist you in conducting the meetings of your committee, I wish to present you with this chairman's gavel, which is inscribed, "T. A. Tennyson, Jr., Chairman, AREA Committee 13, 1965–1967."

The committee is now excused with the thanks of the Association. [Applause]

[Vice President Johnston assumed the Chair.]

Discussion on Highways

[For report, see Bulletin 588, pages 89–97]

Vice President Johnston: The next report will be presented by Committee 9—Highways, the chairman of which is R. W. Mauer, special engineer, Atchison, Topeka & Santa Fe Railway, Chicago. Will Mr. Mauer and the members of his committee please come to the platform.

Mr. Mauer, you may proceed.

Chairman R. W. Mauer: Mr. President, members of the Association and guests:

The report of Committee 9—Highways, appears in Bulletin 588, Vol. 66, pages 89–97, incl., published in November 1964. Your committee submits progress reports on six assignments. Following the presentation of reports we are privileged to bring you a special feature. As we proceed your comments are invited.

Assignment 1—Revision of Manual

Chairman Mauer: Our report on Assignment 1 will be presented by R. E. Skinner, staff engineer, Illinois Central Railroad.

R. E. Skinner: At our Annual Meeting in March 1964, your committee reported that a letter ballot had been approved for submittal to the committee membership for the elimination from the Manual of the 6-ft, 50-deg type of highway crossing sign. The ballot was submitted and there were no dissenting votes. Since that time another ballot was approved and submitted to the committee membership for elimination of the wig-wag type of crossing signal from the Manual. This ballot has also received approval of your committee with no dissenting votes.

Basically, what your committee recommends in regard to the crossbuck signs is to eliminate all reference to the 6-ft, 50-deg type and to consolidate the painted with the reflectorized 4 ft, 90-deg type on one plan with appropriate changes in the notes.

Your committee also recommends the elimination of all references to the wig-wag type of crossing signal from the Manual. This type of crossing signal is no longer being manufactured, repair parts are difficult to obtain and the Communication and Signal Section, AAR has eliminated it from its Manual. However, your committee recognizes that some of these signals are still in use, and in order to protect those railroads still having wig-wag signals in operation, "saving clauses' recommended by the AAR Law Department are to be included at the bottom of page 9–3–1. These clauses read as follows:

Note—The practices contained in Part 3 of Chapter 9 of the Manual are recommended for new installations or when general replacement of present apparatus is to be made. State or provincial law will govern where there are differences in requirements from any of these recommendations.

These recommendations are in the interest of establishing uniformity in traffic control and safety devices at railroad–highway crossings, and they do not, in any way, imply or otherwise suggest inadequacy of installations which may not conform to the provisions of this Manual.

Like "saving clauses" are also to be inserted at the bottom of page 9–2–1 to provide protection to railroads having in service highway crossing signs conforming to previous designs.

All other changes recommended are editorial or to eliminate reference to AAR Signal Drawings that are no longer in the Signal Manual.

Are there any questions?

Mr. President, I move that Committee 9's recommendations for Manual revisions, as published in Bulletin 588 on pages 90 through 92, be adopted.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 2—Merits and Economics of Prefabricated Types of Highway–Railway Grade Crossings

Chairman Mauer: Subcommittee Chairman W. A. Buckmaster, assistant division engineer, Baltimore & Ohio Chicago Terminal Railroad, will present the report on Assignment 2.

W. A. Buckmaster: Mr. President, Mr. Chairman, members and guests:

For a number of years your committee has accumulated information in regard to the merits and economics of prefabricated types of grade crossing materials. An analysis of these data was made and an extensive report thereon was published in Bulletin 581.

It has proven very difficult, if not impossible, to give a reliable dollar value to the costs of installation and maintenance for comparing the economics of the various types of grade crossing materials. However, we recognize that this is an important subject and that we should continue our investigations, especially with respect to the rubber-panel-type crossing, the increasing use of which is apparent.

This is a status report, submitted as information, and your committee recommends that the subject be continued.

Assignment 3—Merits of Various Types of Highway–Railway Grade Crossing Protection

Chairman Mauer: Subcommittee Chairman J. A. Jorlett, structural engineer—New York Improvements, Pennsylvania Railroad, will present the report on Assignment 3.

J. A. Jorlett: The report on this assignment appears in Bulletin 588. The committee has not advanced its statistical studies of highway–railway grade crossing accidents that have occurred in the State of Ohio. We have reported in the past that our studies indicate we should attempt to derive statistically the hazard ratings for those crossings in the State of Ohio where the types of protection have been changed from that existing in the period 1949 through 1958. This study would supplement the report of the Armour Research Foundation entitled "Analysis of Railroad Crossings and Accident Data for the State of Ohio during the 10 year period, 1949 through 1958."

Since the publication of our information report in Bulletin 588, Alan M. Voorhees Associates, Consulting Engineers, have completed an interim report on Objective 1 of Project 3–8, "Factors Influencing Safety at Highway–Rail Grade Crossings," a National Cooperative Highway Research Program of the Highway Research Board. The consultants have now been awarded a second contract for $75,000 to progress Objectives 2 and 3. The first two objectives are spelled out in Bulletin 588. Objective 3 is as follows:

> "Explore for new hardware or other innovations which might provide more effective and more economical means (devices, techniques, etc.) of protection."

Full accomplishment of the project is expected by mid 1966. Your committee is to receive reports as they are officially released.

The first meeting of the Special Joint Committee to consider Items 6 and 7 of ICC Report in Docket 33440 having to do with the prevention of highway–railway grade crossing accidents was held in December 1964. The committee approved the distribution of a questionnaire to the chief operating officer of the AAR Member Roads to determine the policies of the various railroads with respect to warning time given operators of motor vehicles of the approach of trains to grade crossings. Item 7 of the ICC report recommends that: "The railroads establish adequate, uniform warning time of not less than 20 seconds to operators of motor vehicles of the approach of trains to grade crossings."

There has been no meeting since to review these replies or to continue work on the assignment.

Achievements of these noted assignments will complement some of the pursuits of this committee. Although several state highway departments and the Bureau of Public Roads are using upgraded formulas for determining hazard indices of highway–railway grade crossings and ordering improvements in various types of warning devices for which the railroads are required by law to bear part or all of the costs, the formulas are largely empirically derived. Our statistical studies tend to show that even when a few factors that bear a significant correlation to the occurrence of accidents at highway–railway grade crossings are used to determine a hazard rating, the use of the more expensive type of warnings do not appear to materially lessen the hazard.

We wish to study the reports on the two allied assignments when they become available and to carry out the program mentioned in the first paragraph when funds become available; therefore it is our recommendation that the assignment be continued.

Assignment 5—Extent of Use and Effectiveness of Highway-Type Stop Signs at Highway–Railway Grade Crossings

Chairman Mauer: Subcommittee Chairman C. A. Christensen, engineer of public works, Chicago, Burlington & Quincy Railroad, will present the report on Assignment 5.

[Mr. Christensen then read the report on Assignment 5 as printed on pages 94 and 95 of Bulletin 588, November 1964.]

Assignment 6—Methods of Providing Additional Advance Warning to Highway Traffic Approaching a Highway–Railway Grade Crossing

Chairman Mauer: In the absence of Subcommittee Chairman C. W. Traister, grade crossing engineer, Erie Lackawanna Railroad, the report will be given by Vice Chairman Raymond Dejaiffe, chief engineer, Toledo Terminal Railroad.

Raymond Dejaiffe: A report of the activities of this committee was published on page 96 of Bulletin 588. This report indicates that a follow-up inquiry had been addressed to the chief administrative officers of all state highway departments to supplement the information in our earlier report published in Bulletin 581, Vol. 65, November 1963.

This inquiry requested the latest appraisal of the effectiveness of certain special devices installed on the approaches to highway–railway grade crossings, together with information relating to the type, design, location and description of the signs or signals developed by the individual states since their last replies.

The follow-up letter produced replies from 47 out of 49 states in varying degrees of enthusiasm and completeness. Your committee is presently engaged in an analysis of the data submitted by these 47 states and in the preparation of a report on its findings to the Association.

This is a progress report, submitted as information, and your committee recommends that the subject be continued.

Assignment 7—Conduct Study with the View Toward Developing Alternate Types of Automatic Crossing Protection

Chairman Mauer: In the absence of Subcommittee Chairman C. I. Hartsell, division engineer, Chesapeake & Ohio Railway, K. E. Wyckoff, assistant to chief engineer, Great Northern Railway, will present the report on Assignment 7.

K. E. Wyckoff: This report is presented, as information, on developments in the automatic crossing protection of highway–railway grade crossings. The following three items warrant presentation for your consideration:

1. A supplemental signal to the standard flashing lights calling the attention of motorists to the fact that they should continue to "Wait" for a second train approaching the grade crossing. This is being used in place of the addition of gates at crossings with two or more tracks.
2. A grade crossing predictor, which is, generally speaking, a modern electronic system designed to replace bonded track circuits with its numerous insulated joints, and the additional timing circuits. This style is of particular value in situations involving a variety of train speeds and excessive operation of crossing protection.
3. The overlay circuit is a separate and distinct track circuit that can be superimposed on the present track circuits without the addition of insulated joints. It is valuable in welded rail territory, also in those areas where additional flashing-light signals must be installed within other track circuits.

Although detailed technical information is not presented, we wish to call your attention to the opportunities available to minimize the number of insulated joints, thus resulting in more economical maintenance.

Your committee recommends that this subject be continued.

Chairman Mauer: Committee 9 will now present its special feature. I shall ask Frank Barker, assistant chief engineer—system, Santa Fe Railway, to introduce our speaker.

F. N. Barker: Mr. President, Chairman Mauer, members of the American Railway Engineering Association and guests:

One of the most important developments of recent years in connection with grade crossing accidents is the exhaustive investigation made by the Interstate Commerce Commission into the prevention of rail–highway grade crossing accidents involving railway trains and motor vehicles. In February 1964 the Commission released its report on this study in its ICC Docket No. 33440.

Committee 9 is fortunate to be able to present for a discussion of the report of the Commission an attorney who throughout the 20 days of hearings played a leading role in the investigation, the examination and cross-examination of witnesses and, I suspect, in the preparation of many statements and exhibits used by them. He is truly an authority on Docket No. 33440.

Our speaker is a native of the State of Iowa, a graduate of the College of Law, University of South Dakota, an ex-Marine and an eminent lawyer.

It has been my privilege to be acquainted with and in some way associated with him for many years. During that time I have observed with respect and admiration his diligence in promoting the interests of the railroads in the national Congress, in state legislatures, in negotiations with employee groups, and in the defense of railroad interests in litigation and hearings of various sorts. He has no peer in these fields of operation.

It is a pleasure to present to you on behalf of Committee 9 its distinguished guest and speaker on the subject "ICC Report on Prevention of Grade-Crossing Collisions," Joseph H. Hays, general counsel of the Association of Western Railways. Mr. Hays.

The ICC Report on Prevention of Grade-Crossing Collisions

By JOSEPH H. HAYS

General Counsel, Association of Western Railways

Railways and highways are the two major networks for surface transportation serving all parts of the nation. Both are essential to the public interest. They intersect each other at some 224,000 places within the Continental United States. Problems which grow from that simple fact are included among those with which you must deal. You share your responsibilities in this area with railroad operating men and officials, with safety officers and with special police, and you negotiate and work with public officials having jurisdiction over roads and streets and highway traffic safety.

You and your colleagues are to be congratulated, for you are the only group of people dealing with highway traffic safety which has gained in the race with death. Those of you in this work who try so hard to keep people from killing themselves at grade crossings have actually reduced the number of grade crossing fatalities over the past 18 years from 1703 in 1947 to approximately 1500 in 1964. Yours is the only field in highway traffic safety where fatalities have gone down instead of up. You have gone counter to the national trend. And you have accomplished this result in the face of the most dramatic increase in exposure to collision which has occurred in modern times. We must repeat these facts publicly, over and over again, so the public will finally come to know and appreciate what you have done and what can be done.

But you have no room for complacency. Last year an average of nearly 125 people were killed each month in grade-crossing collisions. Fatalities increased in 1964 when there were about 1500 deaths (the final figures are not yet available) as compared with 1963 having 1302 and with 1962 when there were 1182. You have much which remains to be done and you must continue to press every effort to protect drivers from their own folly. In 1964 there was an increase in the total number of highway traffic fatalities to the appalling figure of some 48,000—an all-time record. So grade-crossing deaths still remain only about 3 percent of the total, but there are enough of them to require our continuing concern.

In your approach to a solution of these grade-crossing problems you have received an assist which I am sure you recognize as one of tremendous importance. I refer to the report of the Interstate Commerce Commission, released a little more than a year ago in its investigation into the prevention of rail–highway grade–crossing accidents.* After almost three years spent in the most exhaustive investigation of that subject ever conducted, the Commission came forth with well reasoned conclusions of profound significance. I am sure that most of you are familiar with the report, and I will not bore you with a detailed discussion but there are some aspects of the proceeding which warrant consideration here.

As you might not know, the request for the investigation grew out of a tragic accident near Bakersfield, Calif. where a tank truck pulling a tank trailer, both units hauling crude petroleum, was driven into the path of an approaching passenger train. Fourteen people were killed, including the engine crew and the truck driver, and there were some 106 burned and otherwise injured. There were similar accidents, in fact too many of them, involving petroleum which followed in quick succession, but it was the Bakersfield incident that sparked the demand for action, I know, because I was among those present in the conference when the chiefs of the five operating brotherhoods announced their intention to file with the Commission their petition for the investigation. Yet in the face of this tragic experience, and many others like it, the trucking industry today is pressing with all its energy for the adoption of laws in the several states and the Congress which would allow to be operated in all states the truck train or double-bottom two-unit type of truck-trailer combination which was involved in that collision at Bakersfield. I believe that trains should be operated over steel rails and not on the highways. This Bakersfield tragedy illustrates only one of the many reasons for that assertion.

Another more recent development will be of interest to you and of particular concern to the state and local officials with whom you work. Suit has been filed and is pending in the District of Columbia by the American Trucking Associations, Inc., and the National Tank Truck Carriers, Inc., to set aside the report of the Commission in this grade-crossing investigation and to send it back for revision. Throughout the proceeding those two groups, in a vain attempt to divert attention away from their own negligence, sought to put blame for collisions upon the railroads, claiming excess train speed and inadequate warning. They asserted that trains should yield to motor vehicles at crossings and that train speed should be no greater than motor vehicle speed. After careful consideration the Commission found, as a fact, that train speed had little, if anything, to do with the occurrence of collisions, that a high percentage of collisions occurred when the motor vehicle ran into the train, in many of which instances the train was standing still and that in most other cases the train involved was moving at reasonable or even at exceedingly slow speed. It also went on to find that it, the Commission, had no legal power over train operation at grade crossings, that and related action being reserved to the states.

---

* ICC No. 33440, Prevention of Rail-Highway Grade-Crossing Accidents. Served February 10, 1964.

In their suit the tank truckers claim that existing federal statutes should be so construed as to give the Interstate Commerce Commission that power of control, that the Commission was wrong in concluding it did not have such power, and that its general conclusions would have been different had it decided that it did possess such power. Of course it follows that if, by chance, the courts should hold that the ICC does have jurisdiction in this field the counterpart automatically would be applicable, namely, that the states and cities do not have such power. The federal government would have preempted the field. The state commissions and municipal authorities would be powerless to order protection or separations or to participate in the cost. The railroads have intervened in the suit in support of the Commission. So have the states of Illinois, South Dakota, California and Massachusetts, and the National Association of Railroad and Utilities Commissioners has filed its brief as a friend of the court. However, all the state and local officials with whom you work should be alerted to the dangers of the reckless assertions involved in this suit.

The Commission, in this proceeding, made a number of findings, conclusions and recommendations. Perhaps the finding with the greatest economic, social and political impact was that the cost of installing and maintaining rail–highway grade separations and protective devices is a public responsibility and should be financed with public funds the same as highway traffic devices. That conclusion is sound and constructive. Certainly if we are to have and to use both a national system of railroads and a national system of streets and highways, criss-crossing each other at thousands of places with an ever-increasing number of vehicles using them, at faster and faster speeds, the public must, to an increasing and realistic degree make available the funds with which each system may be insulated from the other.

Of course, if everyone obeyed the law, if motorists heeded the warning to "stop, look and listen" before entering a crossing, there would be no grade-crossing collisions. But, unfortunately, too many people just do not react as they should. Your own experience has shown you that too many drivers do not pay attention and that an amazing number will race the train to the crossing or run around gates after they have been lowered. To arrest the attention of thoughtless or reckless drivers, it is increasingly necessary to provide lights, bells and gates or to provide complete grade separations.

I am sure that it is a great comfort to those of you who have encountered frustrations over the years in connection with this problem to find a public body as well informed and as well respected as the Interstate Commerce Commission supporting the arguments you have frequently made in vain.

Naturally, it is your desire to implement the findings and conclusions made by the Commission in this proceeding. Of course, we railroads should be expected to pay toward the cost of protection the benefits we actually receive. But when and if the law makers adopt the views of the Commission and arrange for public funds to defray the principal portion of this cost of protection, the railroads will be relieved of a burden unjustly borne by them for much too long.

My principal purpose in talking with you today is to discuss and to emphasize two of the Commission recommendations specifically addressed to the railroads. You will remember No. 6 and No. 7 as they appear at page 89 of the printed report. To refresh your recollection, the report recommends that:

> "6. The railroads take prompt action to improve maintenance of railroad rights-of-way at grade crossings to provide safer passage for motor vehicles and remove all sight obstructions so as to provide adequate sight distances for motor vehicle operators and train-crews.

> "7. The railroads establish adequate, uniform warning time of not less than 20 seconds to operators of motor vehicles of the approach to trains to grade crossings."

As you may know, the railroads have proceeded to follow these suggestions insofar as they lend themselves to industry-wide treatment. A special committee under the able direction of R. R. Manion, vice president, AAR, is giving its attention to these particular tasks. I am confident that a special survey will show, if it has not already done so, that the automatic signals on every railroad given at least 20 seconds warning of the approach of the fastest trains on main tracks. Switching tracks and those serving industries present somewhat different problems, but I am sure they can and will be worked out.

The clearance of obstructions to the view and the maintenance in smooth condition of the traveled way for safe passage of motor vehicles, are subjects which do not readily admit of industry-wide treatment. Clear rights-of-way and smooth roadways do not stay clear and smooth. They require continuing attention. At the same time, they often involve cooperation with local officials having jurisdiction over the roads or streets at the crossings involved. In cases where buildings or other permanent structures obstruct the view, advance warning along the approaching road or street may be required calling for action by appropriate road authorities. I am sure that each individual road will continue to give proper attention to these fields of action so that at the proper time we will be able to assure the Commission of our compliance with their recommendations. In my opinion, your committee, under the chairmanship of Frank Barker and with the assistance of Hal Hale has done a remarkable job of maintaining liaison and working out problems with the state highway engineers. Similar programs on a local scale doubtless require your attention. Of one thing I am certain: if we expect to be effective in our efforts to implement the excellent features of the remainder of the Commission report, we must demonstrate, conclusively, our good faith by doing our very best to comply with the admonitions specifically addressed to us.

And that brings us to another facet of this important subject. In most states, under the present law, the railroads have the legal obligation to maintain the traveled way of the roads and streets passing over their tracks. Not long ago a railroad was stuck with a jury verdict for $35,000 because there was ice on the roadway approaching the tracks and a motorist skidded into the train. And just who is it that wears out that traveled way? Certainly not the railroad. The Commission found that the installation *and maintenance* of whatever is required to protect automotive traffic as it flows over rail tracks is a public obligation. Now it's a fine thing to have that principle enunciated by such a well respected body as the Interstate Commerce Commission—surely recognition of the basic rights involved is essential—but it means nothing of practical value unless enacted into law by appropriate authorities.

And what is our situation there? In some states, which I shall not mention, the authorities have quietly gone ahead to assume all or a large share of the cost of maintaining the traveled way over railroad crossings with local roads. In one instance I know of, a whole series of automatic devices is being installed, with the state and local authorities participating in the cost and the title to the devices, under the terms of the contract, vested in the public authority. There are bills pending in the state legislatures under which the cost of maintaining all crossings and crossing protection would be divided on the same basis and among the same parties as the cost of installation.

Surely there is ample moral basis for such relief, but in my opinion there is at least one fundamental requisite to any program aimed at the matter of crossing maintenance. There must be some means for providing public authorities with the money with which to do these things. Few of the cities or counties have funds to do the job, so it seems clear that any measure to cover the public obligation for installation and maintenance must, in the same act, provide revenue to be specifically available to the authorities who are to have the responsibility.

While we may argue about the matter of which comes first—relief on the cost of installation or relief on the cost of maintenance—it seems clear to me that both objectives go hand in hand. If we get the kind of help we need for installation without help for maintenance, we'll be in the same position as the man whose bargain-hunting wife drove him into bankruptcy saving him money. The more protective devices and separation structures we get, the more we must spend to maintain them. Certainly the same logic that justifies public assumption of the cost of protective devices carries with it cost of maintenance. It's all for the protection of the motor vehicle.

There are various plans which have been used to handle the matter of public participation in grade-crossing protection. Perhaps the most outstanding is the plan used in Illinois under which the legislature creates a grade-crossing protective fund to be administered by the State Commerce Commission. Some $50,000 per month is taken from gas tax collections and paid into the fund. The commission may use the money to pay all or any portion of the cost of automatic protection. The funds may not be used on state or Federal aid highways where other funds are usually available. The commission has the power to order protection and, importantly, has the power to close crossings not deemed to be necessary. Remarkable success has been achieved under this plan. Grade-crossing collisions and injuries and deaths therefrom have been materially reduced.

In a most recent study of some 300 crossings where protective devices financed all or in part from the fund had been in use for more than one year, the results were spectacular. The experience in the number of months each device had been in use a year or more was compared with the experience at each of the same crossings for an identical period before installation. At these 300 crossings some 88 had been killed in the period before as compared with only 8 in the period after.

Somewhat similar plans are in effect in Iowa, Nebraska, Wyoming and Minnesota, with other plans for growing public participation in many other states.

A situation has just come to my attention at another place I shall not name. Under current law the state commission has the power to direct the public absorbtion of 85 percent of the grade-crossing protection involved. A bill is, or was, pending to raise that percentage to 95 percent. There are some 1600 crossings in the state which the commission is about to order protected under the plan. But there seems to be a shortage of trained and competent signalmen to do the work. The railroads are considering the necessity of "farming out" the job of installation. This raises a question of policy which I sincerely hope can be worked out. I have not forgotten that it was the railroad brotherhoods who initiated the ICC investigation and that they have been most helpful in the solution of all aspects of the problem. I remember that the practical value of the ICC recommendations depends upon their acceptance by the public and upon our success, and the cooperation we get, in bringing public understanding of the recommendations made.

A few moments ago I mentioned the fundamental recommendation made by the Commission as to the cost of protecting automotive traffic as it flows over railroad tracks. This is a courageous pronouncement which recognizes and translates some basic changes which have occurred. Motor vehicle registrations and the miles they operate have more than doubled since World War II, while motor vehicle speeds and the miles of high-speed highways have multiplied. Exposure to collision between trains and motor vehicles has grown to astronomical figures not because the number of trains has increased (they have actually decreased), but because, and only because, of the phenomenal growth in motor vehicle use.

As I have said, there would be no grade-crossing collisions if there were no places at which railways and highways intersected each other. But it would cost some $86 billion to separate all such crossings, more than three times the net investment in all Class I Railroads. Certainly the railroads could not be expected to carry any such burden. The evidence in the proceeding showed that even the installation of automatic protective devices at such crossings would cost more than $2 billion and that the cost of their maintenance would be some $200 million each year. The entire cost of keeping millions of motorists out from in front of trains is of such staggering proportions that it must be borne as a public responsibility if we are to have railroad transportation and the requisite degree of safety required in view of the growing complexities of motor vehicle use.

The public highway system in America, with all its connecting links, is the most extensive and the most expensive public works project ever conceived in the history of man. It forms the basis for one of our greatest industries, if indeed it is not the greatest—the automotive industry, considering all its ramifications. The use of this system has spelled the demise of one railroad after another in the transportation of passengers. It is something of a miracle that the railroads have been able to survive at all in the face of the smothering competition from highway transportation operated over highways provided at public expense. It is only just that tax revenues generated from the use of this vast highway system (and the total required would be only an insignificant percent of total receipts) should be used to defray the cost of making such highways safe at the thousands of places they intersect the railroads. We need make no apology in seeking fair play for these railroads operating as privately owned, tax-paying, privately operated and privately financed institutions and as surviving segments of free American enterprise as we know that term and as we like to think of it. [Applause]

Chairman Mauer: Thank you, Mr. Hays, for your informative talk directing attention to this important ICC report as it concerns the railroads and all who are engaged in efforts to reduce hazards at highway–railway grade crossings. We appreciate and applaud the dedication you demonstrate in defense of the railroad industry.

This March 1965 Convention of the Association marks the end of my term as chairman. I want to express my sincere thanks to the members of the committee for their splendid help and cooperation during the past three years. Also, I gratefully acknowledge the excellent assistance and guidance received from the executive secretary of the Association and his staff.

It now gives me pleasure to introduce the new officers of Committee 9. Our new secretary will be C. A. Christensen, engineer of public works, Chicago, Burlington & Quincy Railroad. The new vice chairman will be R. E. Skinner, staff engineer, Illinois Central Railroad, who has done a superb job as secretary of the committee for the past six years. Will you gentlemen please rise and be recognized.

My final official act is to present my successor as chairman, Raymond Dejaiffe, chief engineer, Toledo Terminal Railroad.

As an able vice chairman for the past three years, and as subcommittee chairman in past years, Mr. Dejaiffe has demonstrated interest and loyalty in the work of our committee. He will make an outstanding chairman. Mr. Dejaiffe, will you please stand? Thank you.

Mr. Vice President, this concludes our report.

Vice President Johnston: Thank you, Mr. Mauer, and members of your committee, for your interesting and informative reports. Your committee deals with a wide variety of problems in the various aspects of highway–railway grade crossing construction, protection and maintenance. The solutions to the problems are vital to both the public and the railroads.

Mr. Hays, I want to extend to you the grateful thanks of the Association for your remarks on this very serious and important subject. It is our fervent prayer that means will be found to prevent grade-crossing collisions. I know your discussion of the ICC report relating to these accidents has made all of us more aware of our obligations.

Mr. Mauer, we appreciate the able and dedicated leadership that you have given to Committee 9 for the past three years. As you are relieved of your responsibilities as chairman, we are pleased to welcome Mr. Dejaiffe as your successor and Mr. Skinner as the new vice chairman. We are satisfied from their past performance that under their direction the good work of your committee will continue.

Mr. Dejaiffe, as a symbol of your new authority, and to assist you in conducting the meetings of your committee, I would like to present you with this chairman's gavel. The inscription reads: "Raymond Dejaiffe, Chairman, AREA Committee 9, 1965–1967".

Mr. Mauer, your committee is now excused with the thanks of the Association. [Applause]

Discussion on Contract Forms

[For report, see Bulletin 588, pages 153–165]

Vice President Johnston: Next we shall hear from Committee 20—Contract Forms. The chairman of this committee is J. L. Perrier, division engineer, Chicago & North Western Railway, Chicago. Will Mr. Perrier and the members of his committee please come to the platform. Those subcommittee chairmen making reports should take the seats nearest the podium. Mr. Perrier, you may proceed.

Chairman J. L. Perrier: Mr. President, members of the Association and guests:

Committee 20—Contract Forms, was given eight assignments for study and research, and the reports on them were published in Bulletin 588, Vol. 66, November 1964.

Assignment 1—Revision of Manual

Chairman Perrier: This subcommittee, headed by Ken Silvey, area engineer, Pennsylvania Railroad, again reviewed the material in Chapter 20 of the Manual; and while there are some revisions that might be recommended, they are of an editorial nature and are not of sufficient importance to warrant the expense of reprinting. This assignment will be continued.

We extend our thanks to Mr. Silvey and the members of his subcommittee.

Assignment 2—Form of Agreement Covering Purchase and Application of Weed Control Chemicals on Railway Property

Chairman Perrier: The report on Assignment 2 will be made by Subcommittee Chairman E. A. Graham, assistant chief engineer, Colorado & Southern Railway.

E. A. GRAHAM: Mr. President and gentlemen, your committee prepared a form of agreement to cover chemical control of vegetation on railway property which was published in Bulletin 588, November 1964, pages 154 to 158, incl. Having received letter ballot approval of the committee, the agreement form is now presented for adoption and publication in the manual.

Mr. Vice President, I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 3—Form of Agreement for Lease and Operation of Rail Trailer Terminals

CHAIRMAN PERRIER: This subcommittee, headed by F. M. Jones, assistant engineer, Milwaukee Road, has been assembling basic data on this subject and expects to be able to present a comprehensive form of agreement in the near future.

Assignment 4—Form of Agreement to Cover Disposal of Surplus Railway Facilities

CHAIRMAN PERRIER: Report on Assignment 4 will be made by Subcommittee Chairman C. W. Smith, assistant engineer Chesapeake & Ohio Railway.

C. W. SMITH: Mr. President, Mr. Chairman, members, guests:

Last year Committee 20 completed and submitted to the Association as information a form of agreement to cover disposal of major surplus railway facilities. The form was published in Bulletin 588, Vol. 66, November 1964. To reiterate the invitation extended in that Bulletin, Committee 20 would be pleased to receive your comments and suggestions.

Assignment 5—Form of Lease for Railway Property Used for Unloading, Handling and Storing Liquefied Petroleum Gases, Anhydrous Ammonia and Other Flammable or Dangerous Materials

CHAIRMAN PERRIER: The report on Assignment 5 will be made by Subcommittee Chairman J. J. Baffa, division engineer, Pennsylvania Railroad.

J. J. BAFFA: Two years ago your committee submitted a report on this assignment as information, which report was published in Bulletin 574, November 1962, with a request for comments and suggestions. A number of comments were received and given due consideration.

Your committee now submits the form of agreement as printed in Bulletin 588, November 1964, pages 161 to 164, incl., for adoption and publication in the Manual, and I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 6—Form of Agreement Covering Reimbursement for Preliminary Engineering Expenses

CHAIRMAN PERRIER: Report on this assignment will be made by Subcommittee Chairman J. D. Taylor, assistant to vice president, Great Northern Railway.

J. D. TAYLOR: A report on this assignment, submitted as information, was published in Bulletin 581, Vol. 65, November 1963, with a request for comments and suggestions. Your committee now recommends that the form of agreement presented in that report be adopted and published in the Manual at the end of Part 7, Chapter 20.

I move that the form of contract as previously published be adopted and published in the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 7—Bibliography on Subjects Pertaining to Contract Forms

Chairman Perrier: Subcommittee 7, headed by J. T. Evans, engineer—operating agreements, Pennsylvania Railroad, has continued its review of material pertinent to this assignment, but has no report to submit at this time. The assignment will be continued.

Assignment 8—Form of Agreement to Cover Lease of Railway Company Machinery, Tools and Materials to Other than Railway Companies

Chairman Perrier: Chairman J. C. Miller, assistant engineer special projects, Western Pacific Railroad, and the members of his subcommittee have assembled a large amount of data on matters relative to this assignment, and have prepared a preliminary draft of their report. It is expected that a complete report will be ready for publication at an early date.

Chairman Perrier [continuing]: I would like to take this opportunity to personally thank all of the members of Committee 20 for the fine work they have done and the cooperation they have shown in carrying out their assignments.

The concluding item of business in the report of Committee 20 is to announce that our vice chairman, Charles L. Gatton, assistant to engineer maintenance of way, Louisville & Nashville Railroad, has found it necessary to resign from the committee. I am sorry to have Mr. Gatton leave us. He has been a good member. At the same time I am pleased to announce that J. T. Evans, engineer—operating agreements, Pennsylvania Railroad, has accepted the vice chairmanship. Mr. Evans, will you kindly rise. Thank you.

Mr. Vice President, this concludes the report of Committee 20.

Vice President Johnston: Thank you, Mr. Perrier, and the members of your committee for the valuable work of this committee during the past year on this important matter of contract forms. We know you will continue to make valuable contributions to the work of the Association in the year ahead.

Mr. Evans, we want to extend to you our congratulations and best wishes in your new position as vice chairman of this committee.

Mr. Perrier, your committee is now excused with the thanks of the Association. [Applause]

[President Burris resumed the Chair.]

Discussion on Electricity

[For report, see Bulletin 590, pages 339–444]

President Burris: The last report of today will be presented by Committee 18—Electricity, the chairman of which is J. J. Schmidt, assistant director of research, Denver & Rio Grande Western Railroad. Will the subcommittee chairmen making reports please take seats nearest the podium.

Mr. Schmidt, the microphone is yours.

Assignment 1—Revision of AAR Electrical Manual

Chairman Schmidt: Subcommittee 1, whose chairman is P. O. Lautz, assistant electrical and shop extensions engineer, system, Atchison, Topeka & Santa Fe Railway, Topeka, Kan., has been working on an extensive revision of that part of the Electrical Manual covering Wiring Diagrams for Rolling Stock. The specific recommendations are printed on pages 340–343 of Bulletin 590, January 1964, and I move that they be adopted.

[The motion was duly seconded, was put to a vote and carried.]

Assignment 5—Illumination, Collaborating with Committee 6 and the Mechanical Division, AAR

Chairman Schmidt: I shall call on H. W. Dunn, office engineer, Belt Railway of Chicago, chairman of Subcommittee 5, for his report.

H. W. Dunn: Mr. President, members and guests.

The formal report of Subcommittee 5 is found on pages 323 to 354, incl., of Bulletin 590.

The first part of our report covers maintenance of various types of lamps and fixtures, and is submitted as information.

The second part of our report, beginning on page 345, covers lighting for piggyback yards. The printed report in no way reflects the amount of time and effort put forth on this subject. The results to date have not been too good and your committee will undertake further research on this subject with the ultimate goal of a recommended installation.

This report is submitted as information only.

Assignment 9—Electrolysis and Electrolytic Corrosion

Chairman Schmidt: Subcommittee 9 is chaired by E. B. Hager, assistant engineer, Illinois Central Railroad. Mr. Hager.

E. B. Hager: This year's contribution of Subcommittee 9 is a short article entitled "One Aspect of Underground Corrosion of Metallic Structures," suggesting how one possible source of damage may be eliminated or reduced. A table of metals commonly used in underground structures arranged according to nobility or degree of corrosivity is included.

The article is submitted as information.

Assignment 10—Wire, Cable and Insulating Materials, Collaborating with Mechanical Division, AAR

Chairman Schmidt: The subcommittee handling wire, cable and insulating materials also has prepared some Manual recommendations. The subcommittee chairman is F. T. Snder, foreman, Office of Electrical Engineer, Pennsylvania Railroad. Mr. Snider will report.

F. T. Snider: Mr. President and gentlemen:

Subcommittee 10 submits the report shown on pages 355–427 of Bulletin 590, January 1964. Parts A and B are presented as information; Part C presents revisions to Section 10 of the AAR Electrical Manual.

Part A covers the Fourth Edition of "Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy," which was issued in January 1964. It also mentions that a new standard on ozone-resisting rubber is being prepared by the IPCEA and will be issued in the near future.

Part B presents additional information on trial installations of polytetrafluorethylene on locomotive and car equipment. It should be noted that this material has poor cut-through and abrasion-resistance characteristics, and care must be exercised in its installation. On railroad applications it must be securely fastened or tied down and not be installed in conduits or ducts when vibration is present.

Part C covers revision of Section 10 of the Electrical Manual. This section has been completely reviewed and numerous changes, deletions and additions are recommended.

The revised portions of the Manual are shown on pages 356 through 427 of Bulletin 590.

Mr. President, your committee recommends deletion of existing Chapters 2, 3 and 4 of Section 10 of the Manual and the substitution of revised Chapters 2, 3 and 4 and, in addition, changing the accelerated aging factor to 200 percent on page 5–1–2 of Chapter 5 of the Manual.

I so move.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 11—Electric Heating

Chairman Schmidt: The subcommittee dealing with electric heating has as its chairman R. A. Mather, assistant engineer, signals and electrical, Belt Railway Company of Chicago.

R. A. Mather: Mr. President, Mr. Chairman, members and guests. Your committee's report on electric heating is printed in Bulletin 590, January 1965, pages 427 and 428.

This report only summarizes some of the railway applications of electric heating. Your committee hopes to report to you in more detail within the next two years on these and other applications, and solicits guidance from members with specific interests in these or related fields.

This concludes the report of Subcommittee 11.

Assignment 13—Railway Electrification

Chairman Schmidt: Subcommittee 13, dealing with railway electrification, is chairmanned by B. C. Hallowell, engineer electrical traction, Long Island Railroad.

B. C. Hallowell: Mr. Burris, Mr. Schmidt, members and guests.

Subcommittee 13's report may be found in Bulletin 590, Proceedings Vol. 66, starting on page 428.

On the subject of "Developments in the Field of Electrification (domestic and foreign)," our report includes a brief description of the first outdoor type of silicon-rectifier, enumerating some of the details and advantages. It also states that the New York Central Railroad and New York Port Authority are presently making a study and are considering the use of the outdoor type silicon-rectifier substations at some locations where they intend to make power improvements.

The mechanical department of the Long Island Railroad has developed a new third-rail shoe design which has given excellent performance. The details of this shoe are given on page 431, Fig. 2.

In connection with the construction of the San Francisco Bay area rapid transit system, installation of the experimental track is now under way. Results of the various tests to be conducted will be reported next year.

In Philadelphia the Delaware River Port Authority has granted the money for construction of a 600-v third-rail system 14.5 route miles long, between Philadelphia and Kirkwood, N. J.

The Pennsylvania–Reading and Long Island received new MU car equipment during the past year.

Under "Foreign Developments," our report states that seven countries continued electrification projects, also put into service new types of locomotives.

I trust all the railroads have received copies of the report, "A Condensation of the Last Seven Years of AAR and AREA Reports," which has some valuable information on electrification.

Under "Lessening Cost of Distribution System," our report states that L. B. Curtis, former chairman of this committee, submitted a report to the IEEE on the subject "Standard Engineering for Standard Electrification."

There are 10 important items to be considered, all of which will add up to a lower cost for any future electrification. These items are printed on page 436 of our report.

Several interesting new materials and methods for electrification are also included in our report.

The report includes data on the use of aluminum structures and their advantages in electrification systems.

The article on new materials, processes, components and assemblies starting on page 438 was excerpted from Paper 33A, "Developments in Overhead Equipment," presented at the British Railways Electrification Conference on Railway Electrification at Industrial Frequency, London 1960. It mentions the use of resin-bonded glass fiber, fully protected by PTFE sleeves and terminated by compression ferrules, which weighs a great deal less than the porcelain designs, thereby lessening the weight of the catenary system.

Under "Catenary Maintenance Equipment," our report includes several illustrations of the live-line bare-hand method which will result in labor cost reductions in maintenance work on high-tension facilities.

The committee is indebted to T. B. Kirk, electrical engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad for illustrations of units built by the Milwaukee Road in its Tacoma shops for catenary and transmission line maintenance.

CHAIRMAN SCHMIDT: H. W. Dunn, office engineer, Belt Railway Company of Chicago, will now present our special feature.

H. W. DUNN: Mr. President, members and guests:

It isn't very often that an introduction of a speaker is started with a quotation from the speaker himself, but with your permission, I shall make this an exception.

When I contacted our speaker for a little more information than I already knew about him, he replied, quote, "Feel free to use as much or as little of the attached biography as needed. Personally, I feel that long biographies are time consuming and, in general, a bore to the audience," unquote.

I shall, therefore, just mention a few of the highlights in the career of our speaker, leaving his qualifications to your judgment after you have heard his presentation.

He attended Swarthmore College, graduating in electrical engineering. He served as supervisor of marine electrical installation for Sunship Builders and Dry Dock Company. He was an electrical supervisor for a power plant utility company. He was director of education, Transportation Department, General Electric Company, and for the past ten years has been with this company's Lamp Division, being responsible for lamps, lighting and infra-red applications in all areas of the transportation industry. He is associated with the Association of American Railroads, the Railway Progress Institute, the Illuminating Engineering Society, and the American Railway Engineering Association, and has written several papers on lamps and lighting for the transportation industry.

May I present to you at this time, R. L. Henderson, transportation specialist, Product Planning and Application, Lamp Division of the General Electric Company, Mr. Henderson.

Lighting Is Not a Luxury

By R. L. HENDERSON

Large Lamp Department, General Electric Company

The primary purpose of lighting is to provide efficient, comfortable and safe seeing. Without light, the sense of sight, which brings us information from our surroundings, is useless. It is the amount of light and the manner in which it is used that determines how well we see. Adequate, properly distributed light and normal vision are essential for quick, accurate and easy seeing. Poor lighting reduces our ability to see, which, in turn, reduces our efficiency. Since modern industry is dependent on the efficiency of its workers, good lighting is not a luxury, but an essential tool that has a beneficial influence on the success of the industry.

Case histories indicate that certain important benefits can be expected when lighting levels are improved. For example:

1. Insurance records show that accident rates decline when lighting is improved. This fact has been so well established that some states have adopted industrial lighting codes requiring minimum standards of lighting to insure reasonable safety.
2. Production increases from 5 to 25 percent are typical for companies that have doubled illumination levels from 25 to 50, 50 to 100, and on into the hundreds of footcandles.
3. Fewer scrapped parts and a higher quality of workmanship result when workers can clearly see the task before them.
4. Good lighting discourages unnecessarily dirty and cluttered work areas. As a result, housekeeping and morale are improved.

In a typical case study of improved lighting (Erickson Tool Company), worker effiiency was increased by 10 percent, spoilage reduced by as much as 20 percent and minor accidents by 50 percent.

Management and those involved directly with lighting have often asked, "How much lighting is needed for a task"?

The amount of light needed is dependent on the nature of the task and the ability of the observer to see. For instance, black print on a white background is easier to see than small defects in the weave of cloth. And, the age of the observer must be considered, because as we grow older it becomes more difficult to focus on a task.

Man evolved essentially as an outdoor creature, and his eyes are testimony to that fact. Ideal lighting for work involving visual effort, such as in a general office, would be found in the shade of a tree at noon on a clear, sunny day. The level of illumination would then measure in the hundreds of footcandles. Levels of illumination outdoors, incidentally, can reach 10,000 footcandles in full sunlight, and even overcast days will have levels in the low hundreds of footcandles.

Only in comparatively recent history has man taken his work indoors and continued it after dark on a mass scale. Prior to he 1930's, a man's tasks in offices and factories were illuminated at levels from 1 to 10 footcandles—levels which are regarded today as being very inadequate for these locations. During the past 35 years lighting levels have steadily increased. In the 1930's levels advanced to the tens of footcandles. During the war 50-footcandle installations became quite common, and there were a few 100-footcandle installations. Today, lighting installations of 100 footcandles are common, and there are a few specialized applications where 3500 to 4000 footcandles directly illuminate the seeing task. In the future, we can readily predict that many applications will utilize levels of 1000 footcandles and more.

With present technology we can design lighting installations in the hundreds of footcandles that are visually and thermally comfortable. However, we do not yet have the technological skill to design general lighting systems that will produce thousands of footcandles comfortably and economically. We know through research that there is need for these higher levels of illumination in many applications. Under controlled conditions tests have been conducted that permit people to select the lighting level they prefer. Most people choose levels from 500 to 1000 footcandles and higher, depending on the nature of the task.

Another question often asked is "How are the recommended levels of illumination determined?"

The Illuminating Engineering Research Institute sponsors a number of research efforts on light and vision. This research has been designed to develop a sound basis for practical lighting recommendations. In addition, research on light and vision is being carried on in some 44 educational institutions.

Subcommittee 5 of Committee 18 has the responsibility for establishing lighting methods and levels for the railroad industry. This is not an easy assignment, because the study of lighting practices and seeing involves a number of variables. For instance: people do not have the same ability to see; they have different tolerances to visual discomfort, and they work at tasks that vary in visual difficulty. Some lighting problems and visual tasks are unique to the railroad industry. However, many visual tasks found in this industry are similar to those of other industries and can be treated the same. Subcommittee 5, therefore, not only deals with this industry's specific needs and problems, but constantly keeps abreast of the developments in practically all areas of illumination. The recommendations made by Subcommittee 5 are based upon consideration of a broad range of variables. They cannot be established by simply walking through a shop yard or office, determining visually that any area has too much light or too little light.

One of the most important factors to be considered in selecting a lighting system for a given task is the relation of its value to the user, compared to the cost of the system.

Since the first practical lighting installations, the cost of light has been steadily decreasing. Today's incandescent lamps are ten times more efficient than those of the early Nineteen Hundreds; yet, they cost only one-fifth as much. Similarly, the cost of electricity has dropped to one-fourth of what it was in the Nineteen Hundreds. The first statistical records on the cost of lighting were compiled in 1906, the year the Illuminating Engineering Society was formed. That year, an expenditure equal to 7 percent of a company's payroll was required to provide one footcandle in an office or factory. In 1965, management can provide 200 footcandles in an office or shop for 3½ percent of payroll.

While the cost of lighting is continually decreasing, other costs of doing business—wages, equipment, materials, fringe benefits—are continually rising. Lighting, therefore, is not a luxury but an economic necessity for efficient, profitable human performance at work. [Applause]

[In conjunction with his address, Mr. Henderson, assisted by B. R. Boylan, also of General Electric's Lamp Division, gave a demonstration of modern lamps and lighting.]

Chairman Schmidt: Mr. President, this concludes the presentation by Committee 18.

President Burris: Thank you, Mr. Schmidt. Your committee has done its usual excellent job and has presented some highly informative and interesting reports. We are pleased to see you progressing revisions to the AAR Electrical Manual.

Our thanks also to Mr. Henderson and Mr. Boylan for their most interesting discussion and demonstration. These have contributed much to our store of practical knowledge. Thank you both for your efforts.

Mr. Schmidt, your committee is now excused with the thanks of the Association. [Applause]

President Burris [continuing]: This concludes our program for today, but before adjourning the meeting I have two announcements to make. The first relates to the Annual Election of Officers for the coming year.

J. E. Wiggins, Jr., office engineer, Southern Railway System, has been appointed chairman of the Tellers Committee, which committee will canvass the ballots cast in the election, starting at 7:30 pm in Private Dining Room 11 on the third floor of the Palmer House. All members of that committee are requested to report for duty at that time or as soon thereafter as possible so that the report on the count can be completed by noon and the names of the successful candidates announced at our Annual Luncheon.

The second announcement relates to the convention registration. Up to the present time 1033 men and 871 guests have registered, making a total of 1904.

If there is no other business to come up now, let us consider our day's work done, and report back here tomorrow morning at nine o'clock.

[The meeting adjourned at 5:10 pm]

Morning Session, March 24, 1965

[The meeting reconvened at 9 am, President T. F. Burris presiding.]

Discussion on Iron and Steel Structures

[For report, see Bulletin 590, pages 291–297]

President Burris: The first committee to report this morning is Committee 15—Iron and Steel Structures, the chairman of which is G. W. Salmon, engineer of bridges, Seaboard Air Line Railroad, Richmond, Va.

Since Mr. Salmon and the members of his Committee are already in place on the platform, I shall turn the microphone over to him. Mr. Salmon, please proceed with your reports.

Chairman G. W. Salmon: Mr. President, members and guests:

The annual report of Committee 15 is published in Bulletin 590, pages 291–297, incl.

Assignment 1—Revision of Manual

Chairman Salmon: The report on Assignment 1 will be presented by the chairman of the subcommittee, E. S. Birkenwald, assistant chief bridge engineer, Southern Railway.

E. S. Birkenwald: Mr. President, members and guests:

Your committee submits for adoption Manual material which calls for revision of Arts. 29 and 31, Sec. A; Art. 1, Sec. C, and Appendix A of the Specifications for

Steel Railway Bridges; and Art. 12, Sec. D of the Specifications for Movable Railway Bridges.

The revision of Art. 29 provides a modern interaction formula for members having combined bending and direct stress. The committee has approved this revision by a two-thirds majority in the letter ballot taken.

An editorial revision is necessary to Art. 31 in order to set out properly what is intended. Attention is called to the fact that this article on page 293 has not been revised to set the phrase "For compression members" back to the same identation margin as "For stiffeners", which is the editorial revision intended.

Art. 1, Sec. C, needs editorial revision to clarify the application of the secant formula given in Appendix A for compression members.

Revision of Appendix A, page 15–1–42, is editorial and necessary.

Revision of Art. 12, Sec. D, of the Specifications for Movable Railway Bridges is required to correct an error in the formula given.

Mr. President, I move that these revisions to the Specifications for Steel Railway Bridges and for Movable Railway Bridges be adopted for publication in the Manual, and that, with these revisions, these Parts of Chapter 15 of the Manual be reapproved.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Birkenwald: Your committee presents as information a proposed revision of the impact formulas in the Specifications for Steel Railway Bridges and the Rules for Rating Existing Iron and Steel Bridges.

The use of the present formulas for the past 18 years has shown the desirability for a single impact formula, which will take care of the kind of span for its range of span lengths covered by the specifications and at the same time avoid a separation of rolling and direct effects. In addition, the present formulas do not take into account the reduction in impact resulting from the dampening effect of ballasted decks. The proposed formulas are more suitable for design, are easier to use, will provide values closely approximating those of the formulas for open-deck construction, and will produce values which closely correspond to the service-test data obtained from ballasted-deck construction.

The use of the new formulas in the specifications requires the proposed revision of the rating rules to permit continuation of the allowance made for a decrease in impact resulting from a decrease in train speed.

Your committee proposes to submit these revisions for adoption and publication one year hence.

Mr. Chairman, this concludes the report on Assignment 1.

Chairman Salmon: Thank you, Mr. Birkenwald.

The following subcommittee chairmen are responsible for assignments on which we have status or brief progress reports. Will they please rise momentarily and be recognized as I call their name.

H. A. Balke, Harry Balke Engineers, Assignment 2—Design, Construction and Maintenance of Railway Roadway Signal Supports of the Bridge and Cantilever Types, Collaborating with the Communication and Signal Section, AAR.

J. E. South, chief engineer—structures, Pennsylvania Railroad, Assignment 3—Corrosion of Deck Plates.

E. T. Franzen, engineer of structures, Missouri Pacific, Assignment 4—Truss Bridge Research Project.

M. L. Koehler, engineer of bridges and buildings, Pennsylvania Railroad, Assignment 5—Synthetic Resins and Other Adhesive Materials for Protective Coating and Reinforcement, Collaborating with Committee 7.

R. C. Baker, assistant chief engineer, Chicago & Eastern Illinois, Assignment 6—Preparation and Painting of Steel Surfaces, Collaborating with the Steel Structures Painting Council.

J. G. Clark, president, Clark, Dietz, Painter and Associates, Assignment 7—Bibliography and Technical Explanation of Various Requirements in AREA Specifications Relating to Iron and Steel Structures.

R. W. Gustafson, bridge engineer, Great Northern Railroad, Assignment 8—Specifications for Design of Structural Plate Pipe with Diameters Greater than 15 Ft.

J. C. King, assistant engineer of bridges and structures, Canadian National, Assignment 10—Effect of Continuous Welded Rail on Bridges, Collaborating with the Special Committee on Welded Rail. This is now Committee 31.

Thank you, gentlemen.

I think it appropriate to mention that Assignment 3—Corrosion of Deck Plates, will hence forth be entitled Protection of Steel Surfaces, in order that this subject may be more all-inclusive.

Assignment 6—Preparation and Painting of Steel Surfaces, Collaborating with the Steel Structures Painting Council, has been eliminated. We do, however, expect to continue our collaboration with the SSPC. Unfortunately, the AAR has not been able to offer any financial assistance to the SSPC for the last several years, although they were influential in helping to establish the Council.

We would now like to present our special feature on Welded Railroad Bridges. J. M. Hayes, professor of structural engineering, Purdue University, will introduce the speaker.

Professor J. M. Hayes: Mr. President, members of the American Railway Engineering Association, and guests.

Since the building of the first all-steel bridge in 1878—over the Missouri River at Glasgow, S. Dak., on the line of the old Chicago & Alton Railway—methods of bridge fabrication have received continuous study. The pertinent questions are not all answered—there remain many challenging problems. Your Committee 15, as a part of its continual efforts to solve these problems, is proud to present as its special feature an address on the subject, Welded Railroad Bridges. It will be given by a member of Committee 15 who has designed and constructed several welded railroad bridges, who serves on the American Welding Society Conference Committee on Welded Bridges, and who is chief engineer—structures of the Pennsylvania Railroad. It is our pleasure to present John E. South.

Welded Railroad Bridges

By J. E. SOUTH

Chief Engineer—Structures, Pennsylvania Railroad

The replacement of the heavy locomotives with the much lighter diesels has enabled the railroads to keep in service many of their older and lighter designed bridges that otherwise would have had to be replaced. However, with the rapid trend to heavier cars, the rate of renewal of many of these weaker bridges will, without a doubt, be greatly accelerated.

We have about 9,500,000 track feet of steel railroad bridges in the United States. From the information I have been able to develop about half of these bridges were constructed prior to 1910 and designed for Cooper E 50 loading or less. Since it is quite possible that cars will be constructed having a Cooper rating of E 70 to E 80, many

This new unitzed span was designed to avoid rebuilding the sidewalk bents that supported the old three-span deck girder.

of these older bridges will have to be rebuilt. Even renewal on the basis of 100-year life would require about 95,000 track feet of new steel bridges annually, using about 70,000 tons of steel.

The Pennsylvania Railroad purchased about 4,000 tons of all-welded bridges in 1964 at a price ranging from 13½ cents a pound to 18½ cents a pound, depending on the amount of fabrication duplication and/or the complexity of the design. The average price was about 14½ cents a pound, which price included four coats of paint applied in the shop.

We have shown that an all-welded bridge will weigh about 25 percent less than a riveted bridge of comparable design. I think that when you consider the savings in weight and compare the above prices per pound with what you have been paying for riveted spans, you will agree the potential savings are such that the welded bridge must be considered in any replacement program.

In addition to the direct saving in purchase cost there are many other economies and advantages in welded construction. For instance, a much simpler structure can be obtained, with smooth lines and flat surfaces easy to keep clean, paint and maintain. Welded construction is more versatile, more adaptable to fabrication of almost unlimited shapes, sizes and arrangements of parts to meet specific needs.

The early railroad engineers were the pioneers and leaders in bridge design and construction. Even the first all-welded bridges were railroad bridges. It is difficult to

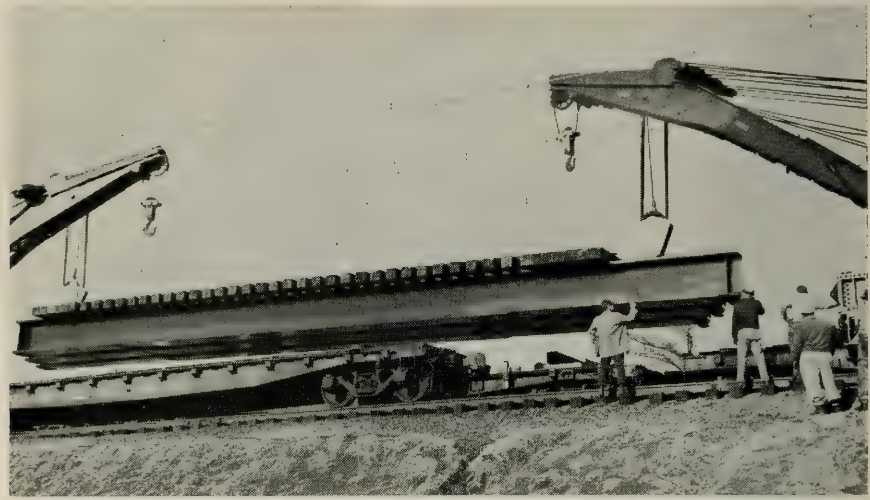
End view of welded span being lowered into position. The ties were all framed and placed before moving the span into position for erection.

understand why we have been so cautious to recent years in making greater use of all-welded bridges, especially since repairs and strengthening by welding has been practiced for the past 30 some years. In carrying out this kind of work, welding processes, details and materials were used that were inferior to those now available. There have been no serious failure from this early welding work.

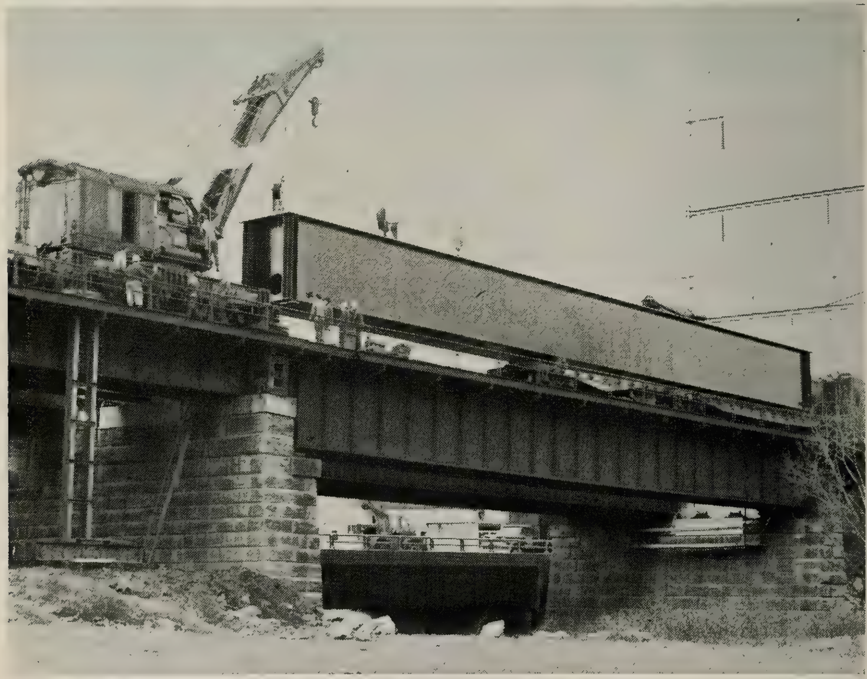
In my opinion, possibly, two principal factors have caused the railroad bridge engineers to hesitate in using the all-welded bridges: the uncertainty of the effect of fatigue and over-emphasis of possible failure due to brittle fracture.

In recent years the study of fatigue of structures has been greatly accelerated, and it is possible that the intensity of this study has been misinterpreted by the engineers and has lead to the belief that fatigue failure was something peculiar to a welded structure. However, in our own literature, and I refer to the AREA Proceedings, Vol. 52, Table 1, on page 122, we show that the fatigue strength of welded fabrication is comparable to that of riveted.

Fatigue strength of a given member depends upon the range of stress from minimum to maximum, the level of maximum stress and the number of stress cycles. Applications of loads producing stresses below the fatigue limit will have little or no effect on the fatigue life. "Fatigue limit" is, "the limiting value of stress below which a material can presumably endure an infinite number of stress cycles."



Welded bridge of shallow design. This span is 71.5 ft long, depth 38 in, giving a span/depth ratio of 22.6 and a design load plus impact deflection-span ratio of 1/527.



A 122-ft-span all-welded box girder bridge—one of four erected on the PRR main line over Chester Creek. Note the smooth surfaces for painting.

In the design of a bridge we provide strength to carry, with a reasonable margin of safety, the maximum anticipated combination of forces. It is possible that the maximum design stresses are reached in only a small percentage of load applications and the fatigue life is never reached during the life of the structure. Further research would be of value to determine the frequency or percentage of loads that produce maximum design stresses or stresses above the "fatigue limit."

Professor W. H. Munse of the University of Illinois, a member of Committee 15, has prepared a book titled, "Fatigue of Welded Steel Structures," published by the Welding Research Council. A better understanding of the effect of fatigue can be obtained from this book.

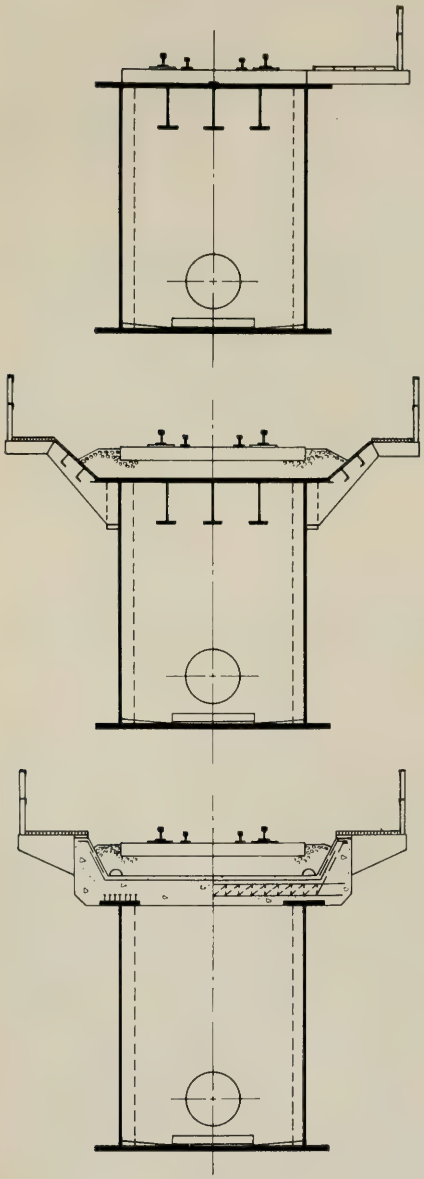
There have been welded bridge failures in the past, caused by brittle fracture. Engineers remember the welded ship failures in World War II. These failures have all been proven to have been caused by use of notch-sensitive steel or by a combination of circumstances, including use of stress-raising details and poor welding procedures. The Welding Research Council publication, "Control of Steel Construction to Avoid Brittle Fracture," is recommended for better understanding of this subject.

Fatigue cracks generally propagate slowly, so they can be discovered by routine inspection before they become serious. Any crack, however, is a severe stress-raising notch that could lead to brittle failure in notch-sensitive material. When the component parts that make up the whole structure are welded together, they no longer are separate pieces but become completely integrated and should be so treated. This, of course, is advantageous in many ways, for it permits more effective use of the material, and parts can be joined that could not possibly be joined by any other method. At the same time new problems are created for the designer. For instance, a crack once started in a welded structure could propagate through the entire member whereas in a riveted structure a crack, in most cases, would only travel as far as a joint between pieces. Fatigue and brittle fracture therefore must be given more consideration in a welded bridge design than a riveted design.

Although this certainly does not present an insurmountable problem, it does emphasize the necessity for selection of details known to have good fatigue strength, to avoid notches or stress-raising details and to specify steel that is known to be notch-tough at low temperature. Fully killed fine-grained steel will add very little to the overall cost of a bridge and will insure a steel with sufficient notch ductility to meet most requirements. Those parts of the structure where extreme notch ductility at low temperature is required can be normalized.

Since structural welding has not become as standardized as riveted work, it is important to select a fabricator thoroughly qualified to do the work in a manner that will satisfactorily meet all requirements of the specifications. Prior to contracting the work, a visit to the fabricator's plant should be made to determine if it is satisfactorily equipped to do the required work, what experience the fabricator has had in welded bridge fabrication and, of importance, discuss with him the welding procedures that you will require be followed and emphasize that he must comply with complete adherence to the specifications. All shop welders should be qualified, and evidence of their qualifications should be produced by the shop.

Good shop inspection is most important to insure a properly welded bridge. In addition to the usual requirements for a structural inspector, a welding inspector should be a qualified welder and, needless to say, thoroughly familiar with the welding specifications. He should permit no changes in the welding procedures without permission of the design office.



These drawings show variations in a welded box-girder design that PRR is considering for future use.

Top—Ties rest directly on the deck in this adaptation. Structures of this kind could be fabricated in sections in both length and depth, and the sections field welded to obtain the desired dimensions.

Middle—Variation with a ballasted deck.

Bottom—Composite reinforced concrete deck.

Welders in your employ who are doing welding repair and strengthening should also be qualified. On the Pennsylvania Railroad we require our welders be qualified in all positions, any thickness of material and in the use of low hydrogen electrodes. At first our welders objected to such stringent requirements, but most of them now take pride in the fact they are better qualified than most welders outside of the railroad. It is important to have the welders fully qualified so that in an emergency no difficulty will be encountered in finding welders for any work required. Otherwise, for expediency, anyone might be used whether qualified or not for the particular work.

In the time available it is impossible to cover in detail the requirements for design of welded bridges that have been learned in the few years of welding experience. This, of course, is only a sketchy outline of the requirements. The design information, weldable steels, welding and fabrication technics are all available so that satisfactory and economical welded railroad bridges are obtainable for the benefit of our industry. [Applause]

Professor Hayes: Mr. South you have made an excellent presentation on the subject of welded railroad bridges—indeed a timely subject. You have shown us that the thinking of the railroad bridge engineer is not archaic—that he is seeking the best way to solve his problems, and that he is on the "firing line" of his profession. The committee appreciate very much the time and effort you spent in preparing this address. I am sure that the members of the Association join with the members of Committee 15 in saying: "Thank you, Jack, for a job well done."

Chairman Salmon: Mr. President, this concludes the report of Committee 15.

President Burris: Mr. Salmon, we thank you and your committee for your usual fine and informative reports. Thank you, Mr. South, for that most interesting talk on welded railroad bridges. I know all those who heard you have gained much knowledge from your remarks.

Mr. Salmon, railroad engineers all over the world look to your committee to keep them apprised of the latest practice in design, construction and maintenance of steel structures. I know you and your committee will keep up the good work.

Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Masonry

[For report, see Bulletin 590, pages 305–323]

President Burris: I now ask Committee 8—Masonry, to come to the front and be seated on the platform.

The chairman of Committee 8 is J. R. Williams, engineer of bridges, Chicago, Rock Island & Pacific Railroad. Mr. Williams, will you begin your report, please.

Chairman J. R. Williams: Mr. President, members of the Association, and guests:

Your committee wishes to express its sorrow at the death of Maurice Coburn on May 8, 1964. He was a Member Emeritus of Committee 8. A memoir in his honor was published in Bulletin 590.

Your Committee on Masonry has reported on six assignments in Bulletin 590, pages 305 through 323. Two of these reports include Manual revisions. In the interest of saving time, I shall call only on those subcommittee chairmen whose reports contain Manual material requiring action thereon, and will ask the remaining subcommittee chairmen to stand and be recognized.

Assignment 2—Design of Masonry Structures, Collaborating with Committees 1, 5, 6, 7, 15, 28 and 30

Chairman Williams: Subcommittee Chairman F. A. Kempe, Jr., assistant bridge engineer, Northern Pacific Railway, St. Paul, Minn., has given a progress report on Assignment 2, as shown on pages 307–310, incl., of Bulletin 590. This report includes a tentative draft of Rules for Rating Existing Concrete Bridges, with the thought that the rules will be presented next year for adoption and publication in the Manual. Comments and criticisms regarding the proposed rules are invited.

Assignment 3—Foundations and Earth Pressures, Collaborating with Committees 1, 6, 7, 15 and 30

Chairman Williams: Subcommittee Chairman G. W. Cooke, consulting engineer, Columbus, Ohio, has given a progress report on three parts of this assignment on page 311 of Bulletin 590. This assignment consists of (a) specifications for imbedment of poles, (b) specifications for sheet pile retaining walls, and (c) a bibliography on the effect of earthquake forces on pier foundations.

Assignment 4—Deterioration and Repair of Masonry Structures

Chairman Williams: The subcommittee chairman is J. M. Williams, masonry inspector, Illinois Central Railroad, Chicago.

This subcommittee has two assignments. The first assignment has been completed and is presented on pages 311–315 of Bulletin 590. This assignment consists of a report entitled "Guide for the Use of Epoxy Compounds in the Repair and Restoration of Concrete," and is presented as information.

The second assignment is revision of Part 14—Repairing and Solidifying Masonry Structures, to include the use of epoxy resins. This assignment is being progressed with the hope of presenting Manual material in the near future.

Assignment 6—Prestressed Concrete for Railway Structures, Collaborating with Committee 6

Chairman Williams: Subcommittee Chairman E. D. Ripple, principal structural engineer, Long Island Railroad, Jamaica, N. Y., will report on Assignment 6.

E. D. Ripple: Your subcommittee during the past year has completed the revision of Part 17 of Chapter 8 of the Manual, "Specification for Design, Materials, and Construction of Prestressed Concrete Structures."

Mr. President, I move the revision of Part 17 of Chapter 8 of the Manual, as published in Bulletin 590, page 316, be approved.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Ripple: Mr. President, I also move that Specifications for Design and Construction of Prestressed Concrete Trestles for Railway Loading, Using Box Beams, published as information in Bulletin 583, pages 364–374, and with revisions published in Bulletin 590, page 316, be approved for addition to the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Mr. Ripple: Your subcommittee presents as information three tentative drawings, Figs. 7, 8 and 9, pages 318, 319 and 320, Bulletin 590, showing details of through-voided single- and double-box prestressed beams.

Prestressed box beams using lightweight aggregate are presently undergoing tests and will be the subject of a future report.

Your subcommittee is now proceeding with the design of longer span prestressed box-beam structures and is continuing its review of Part 17 of Chapter 8.

Assignment 7—Quality of Concrete and Mortars, Collaborating with Committee 6

Chairman Williams: Subcommittee Chairman W. P. Hendrix, engineer of bridges and buildings, Pennsylvania Railroad, Philadelphia, reports progress on the primary assignment of this subcommittee, which is to revise the AREA pamphlet, "Instructions for Mixing and Placing Concrete," and to produce a handbook of practical information for use of field forces in down-to-earth terms that will embody all the principles necessary to produce concrete of the highest quality.

This subcommittee has a continuing assignment of maintaining Manual references to ASTM Specifications and Designations up to date. Necessary revisions have been made and were published in Bulletin 590, pages 322–323.

Mr. President, I move that these revisions be accepted.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 8—Waterproofing for Railway Structures, Collaborating with Committees 6, 7 and 15

Chairman Williams: Subcommittee Chairman R. J. Brueske, division engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Milwaukee, Wis., reports progress on the three parts of their assignment, namely, (a) rewrite Part 3, Chapter 29, Coatings for Dampproofing, (2) investigation of the waterproofing qualities of epoxy resins and related materials, (c) investigation of waterproofing qualities of butyl membranes.

If there are any questions pertaining to our reports, the committee will attempt to answer them. If there are no questions, Mr. President, this concludes the reports on our assignments.

As a special feature of Committee 8, I am pleased to present a man who for many years has been a member of the AREA and also of Committee 8, Dr. Anton Tedesko, vice president of Roberts and Schaefer Company and partner in charge of structures, Urbahn–Roberts–Seelye–Moran (URSAM), who will give an illustrated talk on some of the most fantastic engineering demands in the Space Age. Dr. Tedesko.

Giant Moon-Port Structures Take Shape at Cape Kennedy—(A Member of AREA Describes Work in the Moon Program)*

By DR. ANTON TEDESKO
Vice President, Roberts and Schaefer Company

Years ago, when I joined the AREA, most of the designs of my company were for railroad structures. Later, we designed Air Force structures and air terminals; then came ballistic missile facilities and, most recently, installations for the space program. Today's exciting newspaper headlines dramatically drive home the point that we are making progress in "space transport."

Things are a little different in the space transport field from the way they are on our railroads. In space transport everything is larger than in railroad transport: the loads, dimensions, size of equipment, speeds, and costs are much greater. Our headaches are much greater, too.

The work on space projects has been fascinating for us engineers; it is part of a dream—to set out, like Columbus, to go beyond existing boundaries—the dream to start mankind on its way into space. The moon happens to be closest to the earth, so it logically will be the first "station stop" on our travels.

---

* This is a condensation of Dr. Tedesko's talk, which included the presentation of 32 slides, only nine of which are presented herein.

I have been working on the Apollo Program, on facilities for manned space flight, for 2½ years, and sometimes I still cannot quite grasp the fact, that the dream is becoming a reality. It still is a little like science fiction. Some of our installations at Cape Kennedy and Merritt Island, Fla., are mighty big. As has been stated: "These things must be seen to be *dis*believed!"

General Eisenhower once said, in a discussion of the invasion of Europe, that it is difficult or next to impossible to recreate the climate in which certain vital decisions were made. The same applies to many vital decisions made in the Apollo project. The climate was created by:

—the huge size of the project, the vast scale of the components, the immense size of the loads,
—the tight time frame, less than a year for the design,
—the many people involved in the job,
—the pressure to keep the work on schedule in spite of frequent changes,
—the so-called concept of "concurrency," in which industrial and assembly facilities for rocket components were designed even before the full details of rocket parts, engines, and devices were known.

In the past, and up to now, space rockets were readied on their launching pads. These are the pads with which you are familiar from TV, the pads at Cape Kennedy from which our astronauts took off, on which the space vehicles were assembled; and, where it sometimes took many weeks until all pre-launch operations and tests could be completed. Everything a pilot does before lift-off was done there.

Three years ago, the National Aeronautics and Space Administration (N.A.S.A.) decided on a more economical and efficient manner of handling the huge Saturn space rockets of the Apollo Program. It was decided to assemble and test the vehicle components indoors, in a controlled industrial environment, and to transport the launch-ready vehicle in upright position to a pad where (after fueling) the lift-off will take place. The distance between the pads and the assembly area and nerve center is about 3 miles, as determined by noise and blast-zone considerations.

N.A.S.A. makes use of a rocket-spacecraft combination standing 362 ft high.

The first stage, the booster, weighs 144 tons, empty. Its 5-rocket engines will develop 7,500,000 lb of thrust and will use 4,000,000 lb of kerosene and liquid oxygen.

The second stage will use liquid hydrogen and will develop 1,000,000 lb of thrust.

The third stage will achieve the speed of 17,500 mph (necessary for earth orbit) and will eventually have a speed of 25,000 mph.

The entire space vehicle will weigh 3,000 tons, when ready for lift-off.

The empty space vehicle without fuel weighs 250 tons. It must be erected in a vertical or take-off attitude; the huge hangar with the assembly capacity of four space vehicles has been named the Vehicle Assembly Building (V.A.B.).

Three concepts were considered for the transport of the space vehicle from the hangar to the launch site:

1. Rolling the vehicle on rails supported by heavy concrete foundations.
2. Floating it on a barge in a system of canals.
3. Moving the vehicle on a crawler along a crawlerway, a high-capacity dual road with 6½-ft-thick flexible pavement.

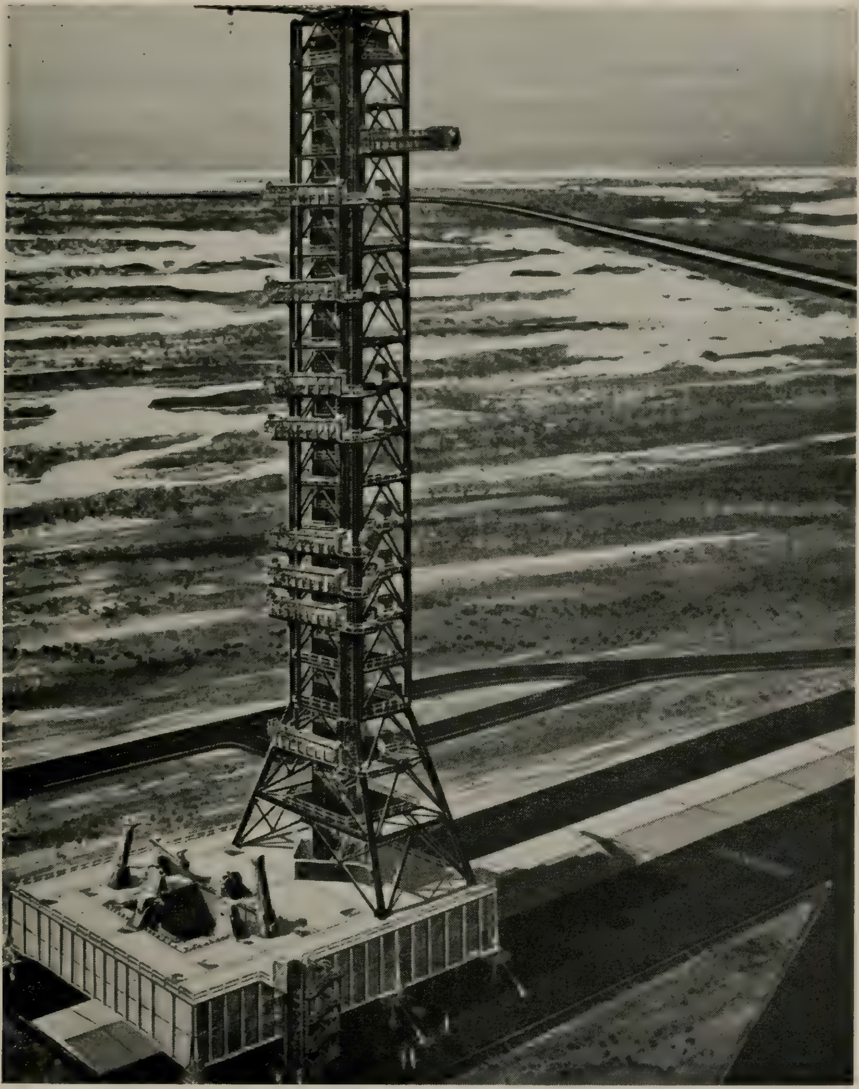


Fig. 1—Mobile Launcher Unit.

The crawler concept was adopted because its cost proved to be the lowest.

The space vehicle will be erected inside the V.A.B. on a 160 ft by 135 ft launch platform incorporating the rocket's umbilical tower (380 ft high) at one end of the platform unit. The entire mobile unit, referred to as a Mobile Launcher (Fig. 1), will be lifted from its place in the V.A.B. by a Crawler-Transporter (Fig. 2) and will be moved with the space vehicle, its computer complex and all, to the launch site,

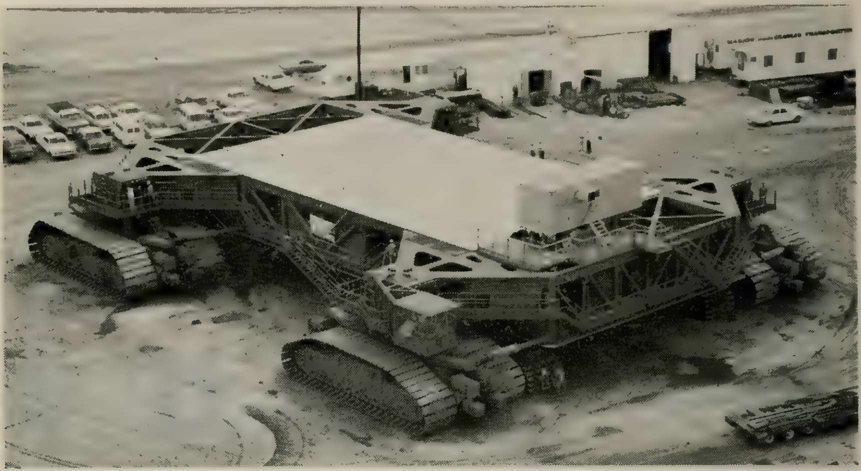


Fig. 2—Crawler-Transporter.

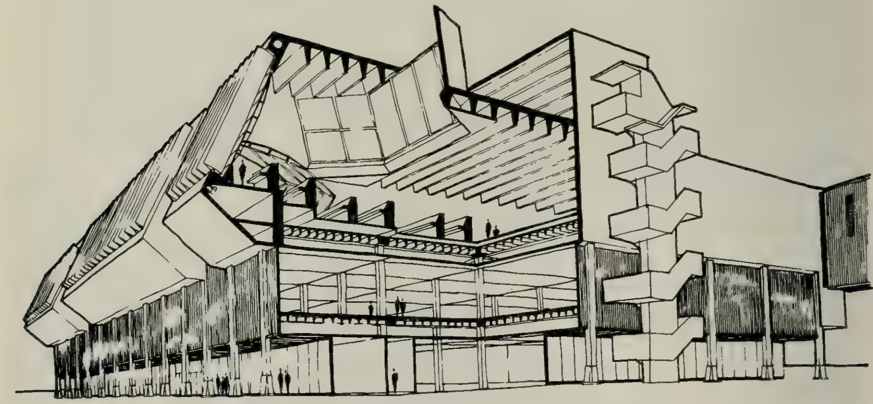


Fig. 3—Launch Control Center.

This load, totalling 17,500,000 lb, will be moved against possible winds up to 46 mph at a speed of 1 mph. The Mobile Launcher provides the base for the actual launch and is designed for the expected temperatures, stresses and vibrations. The essential tested connections of the space vehicle are never separated from the ground support and launch control equipment during the assembly, transport and pre-launch stages.

The nerve center with batteries of instruments for check-out, control, and pre-launch testing is the 4-story Launch Control Center (L.C..C.), a 375- by 182-ft reinforced concrete building, from which the launch operations will be conducted. (Fig. 3)

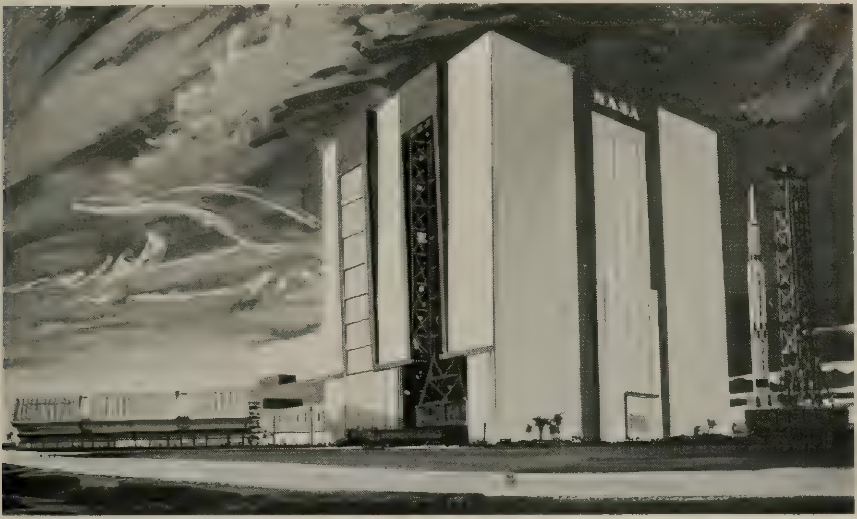


Fig. 4—General arrangement of Assembly Building with space vehicle.

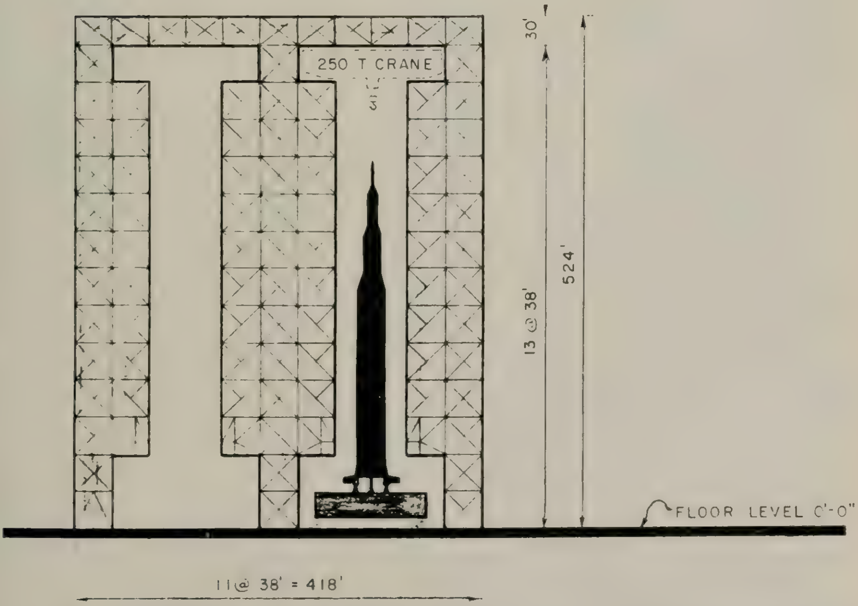


Fig. 5—Structural configuration of one of the north-south sections of the assembly building. Cross sections vary from bent to bent, depending on clearances and operational requirements.

The Vehicle Assembly Building at the John F. Kennedy Space Center, Merritt Island, Fla., is a record-breaking structure. (Fig. 4) Towering 526 ft high, it is large enough for its doorways to admit a 45-story skyscraper. It sets a record for volume enclosed in a single building, and requires about 100,000 tons of steel. (The Empire State Building took 60,000 tons, the Merchandise Mart here in Chicago, 54,000 tons). The building is equipped with 250-ton-capacity cranes with 462-ft hook height. Its foundations required more than 4200, 160-ft-long, 16-in diameter, open-end steel piles, 3⁄8 in. wall thickness. The total length of these piles is 128 miles. The doors of the V.A.B. are 456 ft high, 152 ft wide at bottom, 76 ft wide in upper portion

Many problems were encountered in the consideration of various framing designs. Included among these factors were stiffness and restraint against wind loads, adaptability to changes, ease of connection with future extensions (planning included provisions for a 50 percent increase in size with an assembly capacity for six space vehicles), and above all, the necessity to have the required working room for the operations expected to take place in the building.

The chosen shape is not the most advantageous from the standpoint of shedding wind, but it is economical and good from the standpoint of wind movements which had to be restricted so as not to damage the space vehicle. The structure, as finally adopted, is stiff against wind, with stresses due to volume changes of an acceptable magnitude. It consists of a three-dimensional system of steel trusses and horizontal diaphragms of composite construction, steel beams and lightweight reinforced concrete. Fig. 5 indicates the structural configuration of one of the north–south sections of the Assembly Building. Cross sections vary from bent to bent, depending on clearances and operational requirements. Fig. 6 is a simplified diagrammatic view of the basic truss systems of the Assembly Building (the roof system and all secondary truss systems have been removed for clarity). The high bay of the V.A.B. measures 513 ft by 418 ft. The low bay portion measures 437 ft by 256 ft and is 211 ft high. The high bay has trusses parallel to 3 mutually perpendicular planes, is 2,840 times statically indeterminate; and its basic system has 2,440 joints and 12,400 members.

Fig. 7 illustrates the operational problems and the loads on the structure; it shows the Mobile Launcher and the vehicle inside the structure; it shows the extensible working platforms, which are multi-story retractable shops, moving on cantilever supports to envelop the space vehicle at any desired level.

The following facts may be of general interest: wind forces had a governing influence on the design; wind-tunnel model tests gave useful results; the structure was designed for hurricane forces; electronic computers were of help in the design.

Maximum use was made of rolled sections of structural steel, some heavier than ever before rolled (734 lb/ft). Columns form a box section of about 2 by 2 ft—heaviest sections 1305 lb/ft (Fig. 9). There are 1,200,000 sq ft of horizontal 4-in lightweight reinforced concrete diaphragms in the high bay portion.

The 45,000 steel members required were fabricated in 8 different shops. Connections were shop welded, but 1,000,000 high-strength bolts were used for the field erection.

Doors will open in less than 1 hour, the skin of the building is coated, insulated aluminum, 800,000 sq ft of the floor area is air-conditioned.

Total cost of facilities described in this report exceeds $100 million; 2,700 contract drawings were required; 20,000 shop detail drawings will be used.

Several contractors are proceeding with the construction under the direction of the U. S. Army Corps of Engineers, Canaveral District (Col. W. L. Starnes, district engineer, Fig. 6 (right)—Simplified diagrammatic view of the basic truss systems of the Assembly Building. (The roof system and all secondary truss systems have been removed for clarity).

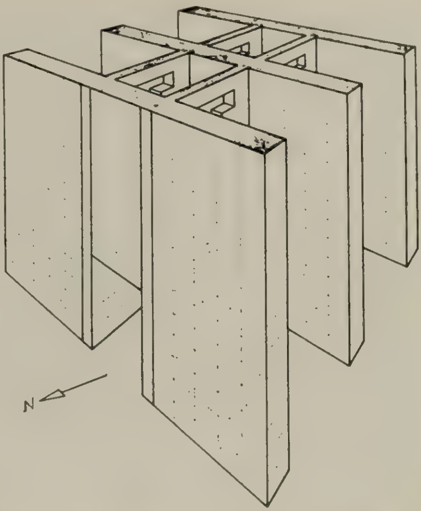
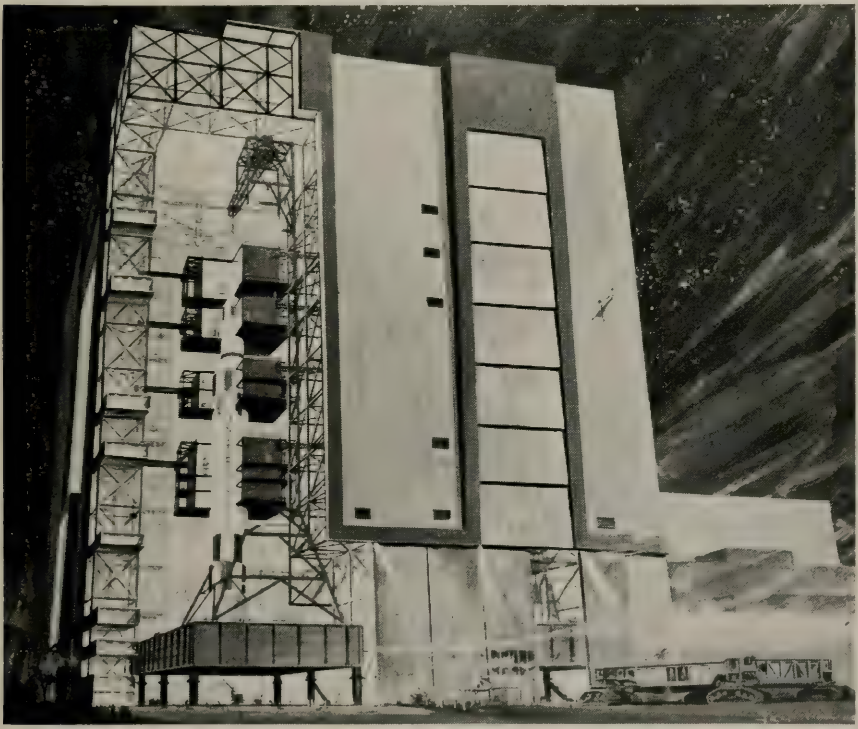


Fig. 7 (below)—Cut-away view showing space vehicle being assembled on Mobile Launcher inside the Assembly Building.



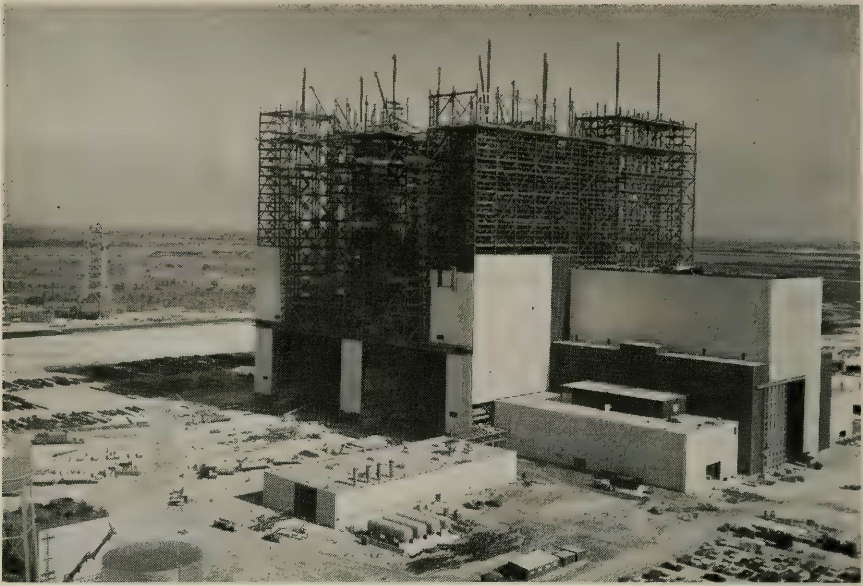


Fig. 8 (above)—Recent construction view of project.

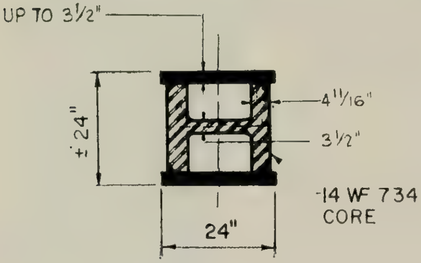


Fig. 9 (left)—Cross section of heaviest column used.

and J. L. Harvey, chief of the Engineering Division) which serves as N.A.S.A.'s design and construction agency

For the work at Merritt Island for N.A.S.A.'s John F. Kennedy Space Center, Dr. Kurt H. Debus is director and Col. A. H. Bagnulo and R. P. Dodd are in charge of Facilities Engineering.

The design was performed by Urban–Roberts–Seelyn–Moran (URSAM), a joint venture of four firms:

1. Max Urbahn (architectural planning, specifications)
2. Roberts and Schaefer Company (structural engineering)
3. Seelye Stevenson Value & Knecht (mechanical and electrical engineering)
4. Moran Proctor Mueser & Rutledge (foundation engineering)

I was in charge of the structural engineering.

It has been fascinating for us civil engineers to work on the space program; in retrospect we can say rather proudly that the decisions made by civil engineers under pressure were pretty good. Our civil engineering technology is well advanced for the support of space travel.

At the present time, space flight, aeronautically speaking, is where the Wright Brothers were 60 years ago. It would be exciting to know where we will be "in space" 60 years from now. We won't know the answer but our children will. What we *do* know is that in all this advancement the civil engineer has had and will have a very important part. [Applause]

CHAIRMAN WILLIAMS: Thank you, Dr. Tedesko, for a most interesting and enlightening talk. I would like to add that we are doubly honored today because Dr. Tedesko's mother came down to hear his address. We are very glad to have her with us. After hearing Dr. Tedesko's talk I don't think we really have any engineering problems in the railroad business. [Laughter]

Mr. President, this concludes the report of our committee.

[Vice President Johnston assumed the Chair.]

VICE PRESIDENT JOHNSTON: Thank you, Mr. Williams, for those interesting and informative reports. We depend on you and your committee to keep us abreast of current advancements in concrete structures and components. That you will do this is assured by the committee's tradition of accomplishments in the past.

Dr. Tedesko, we certainly appreciate your presentation this morning. It is well for us to lift our eyes above our specific railroad problems once in a while to see how the "other half" lives. There is nothing more dramatic and awe-inspiring than the work you have described to us. Thank you for being with us and for your interesting talk.

I would like to make a personal comment. Last April while in Florida I had an opportunity to see some of this from the edges. We were going along on a Sunday and saw a sign near Cape Kennedy reading, "Visitors Welcome," so we took advantage of the opportunity and made a quick tour by automobile. The slides Dr. Tedesko showed were most interesting to me personally. There may be others here who have had the opportunity to take the same quick trip that I did.

Mr. Williams, your committee is excused with the thanks of the Association. [Applause]

Discussion on Impact and Bridge Stresses

[For report, see Bulletin 588, pages 183–185]

VICE PRESIDENT JOHNSTON: The next report will be made by Committee 30—Impact and Bridge Stresses, the chairman of which is J. W. Davidson, engineer of bridges, Chicago, Burlington & Quincy Railroad. Mr. Davidson, will you and the members of your committee please come to the platform. Again, let me remind the subcommittee chairmen who are to make reports that they should sit in the seats nearest the podium.

Mr. Davidson, you may proceed with your presentation.

CHAIRMAN J. W. DAVIDSON: Mr. Vice President, members of the Association and guests:

Committee 30 is pleased to report that considerable progress has been made on its assignments even though research appropriations for the committee's work have been restricted in recent years.

This committee is reporting on four of its ten assignments at this time. All of these are progress reports and are presented as information.

Assignment 2—Steel Truss Spans

Chairmnn Davidson: The AAR research staff had previously made strain gage measurements on a truss span in the Pittsburgh area to determine which members required strengthening to permit operation of 165-ton hot-metal cars. The span was reinforced, and in 1964 further tests were made to find out if the strengthening was fully effective. This investigation was done at the expense of the owning railroad.

Assignment 4—Longitudinal Forces in Bridge Structures

Chairman Davidson: Engineering Research Report ER–48 prepared by the AAR research staff covers field tests on two concrete trestle bridges on the Seaboard Air Line Railroad near Clinton, S. C. As part of these tests, stresses in the piling and in the running rails resulting from traction and braking effects of the test train were determined on one of the bridges. Results showed that the longitudinal forces in this particular case were considerably less than is required for design by the current AREA Specifications. Similar tests were also made to determine braking and traction forces on a prestressed concrete trestle on the Western Pacific Railroad near Stockton, Calif. Here again, measured forces were less than those required by current specifications.

Late last year extensive instrumentation was placed on a 660-ft-long prestressed concrete trestle bridge on the Santa Fe Railway at Dallas, Tex. to determine the effect of longitudinal forces on the structure. This bridge was a very good candidate for such an investigation because of its length and because it was built without any double bents. In previous tests on other bridges it had been found that a major portion of the longitudinal force was carried directly through the rails into the embankment at either end of the bridge. To avoid this effect in testing the Santa Fe trestle, the rail joints were unbolted at both ends of the bridge to isolate the structure before operating the test train. Under these conditions the bridge was found to have a longitudinal movement of approximately ⅜ in.

The oscillograph records of the strain-gage measurements on this bridge are still being analyzed, but it appears from preliminary figures that bending stresses in the piling were not excessive in spite of the extreme test conditions. When the final report on this bridge is complete, it should provide valuable assistance to enable Committee 30 to recommend values of longitudinal forces to be provided for in bridge and trestle design.

Assignment 6—Concrete Structures

Chairman Davidson: Research Report ER–48 covers results of field tests conducted by the AAR research staff on two concrete bridges on the Seaboard Air Line Railroad in S. C. One of these bridges was a 7-span, 134-ft-long conventional reinforced concrete trestle, while the other was a 6-span, 148-ft-long prestressed concrete trestle.

While those who are interested in the full report may find this information in the research report itself, the major findings were that the recorded impacts were considerably less in the prestressed span than in the conventional reinforced concrete structure; further, the impact increased slightly with speed for the conventional design slabs, but remained constant for various train speeds for the prestressed span; that load was distributed transversely almost uniformly across the decks, and that wheel irregularities caused some extremely high impacts.

As a part of its continuing program for determination of impacts on prestressed concrete bridges of various span lengths, tests were made on 42- and 34-ft prestressed box beams on the Chicago & Eastern Illinois Railroad near Danville, Ill., and also on

37- and 24-ft prestressed spans in a Western Pacific Railroad bridge near Stockton, Calif. Reports on these investigations are now being prepared and will be reported later this year.

Assignment 9—Use of Electronic Computers for Railroad Bridge Problems

Chairman Davidson: In 1960 a booklet entitled "Moment and Shear Tables for Heavy Duty Cars on Bridges" was prepared under the auspices of Committee 30 and distributed by the AAR to Member Roads for use in clearing special heavy shipments over the nation's railroads. This information has been well received, and requests have been made periodically for inclusion of additional cars, including cars which have been built since the distribution of the original booklet. Using research funds provided by the AAR, this committee arranged for calculation by electronic computer of the moments and shears for 10 additional heavy-duty cars, and this information was distributed to the chief engineers of the various railroads in December of last year.

A punch-card program deck permitting use of the moving-load program on IBM 650 computers was made available five years ago. Since that time this particular computer has been largely superseded by new, faster models. Accordingly, the AAR has made available a new program deck for use on the IBM 7090 and 7094 computers at a nominal cost of $5 for the program and cards. Due to many requests, a further adaptation of the program to permit use on smaller computers, such as the IBM 1620, has been prepared and is now available for distribution.

I should now like to introduce the subcommittee chairmen. Will each chairman please stand and be recognized as I read his name.

E. S. Birkenwald, assistant chief bridge engineer, Southern Railway; Subcommittee 2.

D. S. Bechly, assistant to engineer of bridges, Illinois Central Railroad; Subcommittee 3.

J. A. Erskine, assistant bridge and building engineer, Gulf, Mobile & Ohio Railroad; Subcommittee 4.

Professor N. M. Newmark, University of Illinois; Subcommittee 5.

P. L. Montgomery, division engineer, Norfolk and Western Railway; Subcommittee 6.

C. V. Lund, assistant to chief engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad; Subcommittee 7.

Professor James Michalos, New York University; Subcommittee 8.

E. R. Andrlik, bridge designer, Atchison, Topeka & Santa Fe Railway; Subcommittee 9.

E. D. Ripple, senior designer, Long Island Railroad; Subcommittee 10.

N. E. Ekrem, assistant bridge engineer, Great Northern Railway; Subcommittee 11.

Mr. Vice President, this concludes the report of Committee 30 and also my term as chairman. The new chairman is N. E. Ekrem, assistant bridge engineer, Great Northern Railway. The new vice chairman is P. L. Montgomery, division engineer, Norfolk & Western Railway. Please accept my congratulations and best wishes, gentlemen.

Vice President Johnston: Thank you, Mr. Davidson and the members of your committee, for the report you have just given and for your continued efforts to assist the other structural committees in this phase of their work.

I think it would be well to extend special thanks to the professors on your committee and those on the other structural committees. Their contributions to Association work are vital to the development of accurate and timely reports and recommendations.

Mr. Davidson, we appreciate the able and dedicated leadership which you have given to Committee 30 for the past three years. As you are relieved of your responsibilities as chairman, we are pleased to welcome Mr. Ekrem as your successor and Mr. Montgomery as the new vice chairman. We are satisfied from their past performance that under their direction the work of your committee will continue.

Mr. Ekrem, as a symbol of your new authority, and to assist you in conducting the meetings of your committee, I would like to present you with this chairman's gavel. The inscription reads: "N. E. Ekrem, Chairman, AREA Committee 30, 1965–1967."

Your committee is now excused with the thanks of the Association. [Applause]

Discussion on Wood Bridges and Trestles

[For report, see Bulletin 590, pages 299–304]

Vice President Johnston: The next report will be given by Committee 7—Wood Bridges and Trestles. The chairman of this committee is B. E. Daniels, division engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Milwaukee, Wis. Mr. Daniels, will you and the members of your committee please come to the platform. The overflow may sit in the seats directly in front of the platform. Again, let me ask that the subcommittee chairmen making reports take seats closest to the podium.

Mr. Daniels, please proceed with your report.

Chairman B. E. Daniels: Mr. Vice President, members and guests:

The complete report of Committee 7 is contained in Bulletin 590, January 1965, pages 299–304, incl.

Some curtailment of the 1964 budget prevented progress on some of our assignments, but we have been active on others. Today we will report on five of our ten assignments.

Assignment 3—Specifications for Design of Wood Bridges and Trestles

Chairman Daniels: The subcommittee chairman, W. L. Anderson, design engineer, Chicago & North Western Railway, Chicago, will present the report.

W. L. Anderson: Mr. Vice President, members and guests:

The report on Assignment 3 appears on pages 300 and 301 of Bulletin 590, January 1965.

Based on data from recent repeated-load tests on full-size timber bridge stringsrs, it was our recommendation, offered for adoption, that the material under Art. 5, Horizontal Shear, page 7–2–12 of the Manual, be deleted, with the substitution therefor of the rewritten version shown on page 301 of the Bulletin.

However, there have been several comments and objections based on information not available at the time of our Bulletin Report. Your committee, therefore, recommends further study by the subcommittee prior to the revision of present Manual material.

This completes my report.

Assignment 6—Applications of Synthetic Resins and Adhesives to Wood Bridges and Trestles

Chairman Daniels: Subcommittee Chairman L. R. Kubacki, area engineer—structures, Pennsylvania Railroad, Chicago, will present the report.

L. R. Kubacki: Your committee submits the following report as information:

The suggested formulations and general instructions for use of epoxy resins, as published under this assignment in the Proceedings, Vol. 64, page 1, are being used by a number of railroads. These formulations are also being tested in the laboratory, and we are continuing our research on the physical properties and applications of some of the formulations.

Laboratory tests have been made on Formulation 991–75 containing a sand filler to determine its crack-filling ability, coefficient of linear expansion, flexure strength and compressive strength. To test crack filling ability, Formulation 991–75, containing various proportions of liquid-to-sand by volume were poured into joint openings varying in width from 1/16 to 3/8 in. To determine the coefficient of linear expansion, flexure strength and compressive strength, 1- by 1- by 15-in test bars were cast from mixtures of this formulation containing the various proportions of liquid-to-sand by volume. Specimens 10 in long were cut from these bars for determining the coefficient of linear expansion and for the flexure tests, and 2-in-long specimens were used for the compression tests. A complete report is being prepared on this investigation.

Laboratory tests were performed on treated timber pile cut-offs, using various epoxy resins. The test procedure consisted of applying the epoxy formulation to the cut-off surface then subjecting the test specimen to wet and dry environments and repeated compressive loading.

It has been determined that an adequate protection for pile cut-offs can be provided by applying a coating of Formulation 991–67, placing a layer of glass fabric on the wet surface and then applying a second coating of Formulation 991–67. This laminated protection provides an adequate seal to the cut-off-surface, a hardened surface, and will withstand repeated compressive loading. Without the glass fabric, the hard epoxy-coating will crack radially with volume changes in the wood. Some variations of Formulation 991–67 and some other prepared products with elastic fillers were tested but they were not satisfactory. A complete report is being prepared on this investigation.

The AAR Research Department submitted Report No. ER 43 in March 1964 covering the inspections on September 25, 1962 and December 27, 1963 of epoxy coated steel plates that had been placed on the Huey Long Bridge. These plates were again inspected during February of this year, and it was noted that the two-coat epoxy systems still offer some protection to the metal. There was some enlargement of the blisters reported in 1963, but compared to other coatings, the two-coat systems are the most effective of those tested. All plates have been left on the bridge and will be inspected again.

The results of the above mentioned laboratory and field tests will be subequently published in reports by the AAR Research Department.

This concludes my report at this time.

Assignment 7—Repeated Loading of Timber Structures

Chairman Daniels: This report was to have been presented by the subcommittee chairman, C. V. Lund, assistant to chief engineer, Milwaukee Road, Chicago, but due to circumstances beyond his control he could not remain for this presentation. D. V. Sartore, vice chairman of this committee, and assistant to chief engineer, Chicago, Burlington & Quincy Railroad, will present the report.

D. V. Sartore: Mr. President, members and guests:

Your committee presents this year a synopsis of tests conducted at the AAR Research Center of full-size glued laminated southern pine bridge stringers, fabricated to a commercial standard. The complete report is published as Research Report ER–52. A previous study of Douglas fir beams was reported to the Convention in 1963.

This series of tests, like the previous series, was designed and carried out with particular respect to determining the effect of load position on strength in horizontal shear. The conclusions reached are similar, namely, that shear resistance, as currently computed, increases as loads approach the support, and is not a constant value as we have long taken it to be in timber design. The critical position is found to be closely approximated when the first heavy wheel load is located at three times the depth of the beam from the support for stringers of the span-depth ratios used in railroad trestles. Average shear strengths developed at 2 million cycles of stress were in the range of 340 to 400 psi, compared to 180 psi currently allowed in glu-lam design, based however on long duration of static loading.

A third series of full-size tests will be undertaken this year, with solid sawn treated fir stringers such as are commonly used. Due to checking, the evaluation of unit shear strength in solid sawn timber is, of course, extremely difficult.

Your committee has been studying the test data made available over the past several years with the view to confirming or modifying allowable working stresses. Until such time as we have completed reasonably sufficient tests on solid sawn full-size stringers, we have concluded that it is prudent to hold any recommendations in abeyance. We feel we need to establish some correlation between full-size beams and the results of the basic tests in repeated loading conducted at the forest products laboratory which were reported to you a year ago.

Assignment 9—Study of In-place Treatment of Timber Trestles

Chairman Daniels: This assignment is being actively pursued by the subcommittee, but due to the lack of funds, such activity is limited to the members and chairman keeping abreast of the progress being made in this matter by various railroads and by the treating industry. I want to recognize the new subcommittee chairman, D. L. Walker, division engineer, St. Louis–San Francisco Railway, Springfield, Mo. Mr. Walker.

Assignment 10—Non-Destructive Testing of Wood

Chairman Daniels: A detailed progress report was made last year. Work on this assignment, as in the case of Assignment 9, has been hampered by a limited budget. Continued interest in devices which will reveal the internal condition of piles and timbers without damaging them, however, obligates this subcommittee and the AAR Research Department to keep in close contact with any industrial developer or researcher who is progressing the study of such equipment.

This subcommittee is under the chairmanship of F. E. Schneider, assistant engineer, Santa Fe Railway, Chicago. Mr. Schneider, will you please rise and be recognized.

Chairman Daniels [continuing]: Mr. Vice President, this completes the reports on the activities of Committee 7 for the past year.

This Committee's program includes a special feature—an address entitled "Performance and Durability of Glued Laminated Railway Bridges." Here to present this subject is a member of the AAR research staff who has been closely connected with this Association and its activities for many years, as well as with the activities of Committee 7, and who is no stranger to this membership.

I am very happy to present Freeman P. Drew, research engineer—structures. Association of American Railroads. Mr. Drew.

Performance and Durability of Glued Laminated Railway Bridges

By F. P. DREW

Research Engineer Structures, Association of American Railroads

Since the early days of railroading, wood has played an important role in the development of the American railway system as we know it today. Over the years there have been significant improvements in materials, fabrication and construction of railway bridges. Spectacular structures were built that demonstrated progress in engineering techniques. Such progress is not limited to steel and concrete, however; timber, also, has been improved through the years, and today has its place as an engineering material. The laminating process is one example of this development.

Glued-laminated timber was introduced to American railroad bridges in 1944 when a panel of glu-lam stringers was installed in a trestle of the Texas & Pacific Railway near Woodlawn, Tex. Since then other test installations have been made in trestles, and several long-span glued-laminated bridges have been built. An inspection of these test installations has indicated that this material is giving excellent service; excessive checking, delamination and glue line separation, though feared, have not developed. During the course of this presentation it will become evident that confidence in the use of this material is justified.

Five test installations were established at the widely separated locations given below to permit periodic observations of the in-service performance of various glued-laminated elements.

1. Texas & Pacific Railway near Woodlawn, Tex., in 1944,
2. Southern Railway at Alexandria, Va., in 1945,
3. Detroit, Toledo & Ironton Railroad near Lima, Ohio, in 1945,
4. Chesapeake & Ohio Railway near Newport News, Va., and at Ameagle, W. Va., in 1946,
5. Southern Pacific Company near Indio, Calif., in 1946.

A brief report on the first three installations was presented to the Association at the 1955 Convention.

Your Committee 7—Wood Bridges and Trestles, requested the AAR research staff to inspect these test installations, and this was done during 1964. Unfortunately, the DT&I installation was inadvertently removed and replaced so no inspection could be made of it. Also, the original test installation on the C&O was dismantled through an oversight. Two stringers were recovered, however, and have been put back in service at a new location in a mine spur near Ferndale, W. Va. These were carefully inspected and photographed by railroad personnel. The other three installations, namely, the T&P, Southern and SP, are still in their original locations and were thoroughly inspected and photographed.

Texas & Pacific Railway

The glu-lam members were installed as stringers in the end panel of a 796-ft-long ballasted-deck trestle No. 55.2, shown in Fig. 1, which runs north and south by compass direction. The stringers are 7 by 16 in, 14 ft long. The species is southern pine and the glue a phenol-formaldehyde resin. After gluing, the stringers were surfaced to size and treated with No. 1 creosote to a net retention of 15.5 lb per cu ft. Additional information on the fabrication of these stringers is given in AREA Proceedings, Vol. 52, page 428.

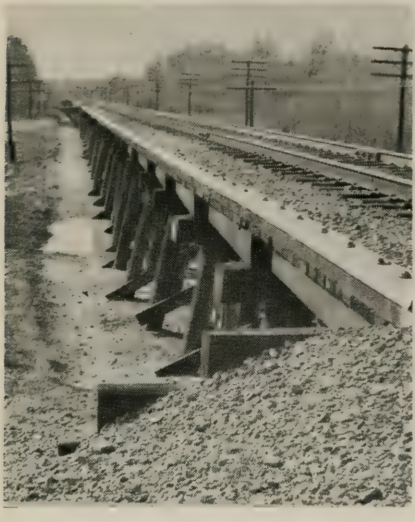


Fig. 1—General view of T&P trestle.

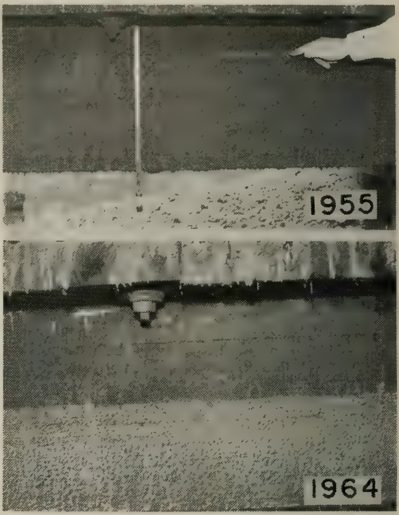


Fig. 2—Close-up view of laminated stringer, south side of bridge.

In general appearance these glu-lam stringers are relatively free of checks and splits compared with the solid-sawn stringers in the adjacent span, which show noticeable checking. The lower view of Fig. 2 shows the east, outside glu-lam stringer as it appeared in the 1964 inspection. A small check was present near the top edge. The check is 33 in long and only $\frac{1}{16}$ in deep. As shown in the upper view of Fig. 2, this check was also seen in the 1955 inspection. Two other small checks were noted on the face of this stringer. All these were in the wood and not along the glue line. The solid-sawn stringer in the adjacent span is shown in Fig. 3. The check shown runs the full length of the member and appears to be no larger now than in 1955.

The glu-lam stringers on the west side had no noticeable checks, nor were any observed on the surfaces of the inside stringers. (See Fig. 4.)

There was considerable bleeding and leaching of the creosote from the stringers, as shown in the figure, and the ground was stained by the preservative.

The south ends of all the glu-lam stringers had some checking and cracking. This was observed in 1955, and is shown in Fig. 5. The vertical crack appears to have been caused by a drift bolt into the cap. The crack was $\frac{1}{8}$ in wide and 6 in deep. The other ends were checked to a lesser degree.

The ends of the solid-sawn stringers were also checked, as shown in Fig. 6. The ends of the solid-sawn cap on the first intermediate bent had wide checks, as shown in Fig. 7.

The following report from the railroad's engineer of structures is indicative of the type of service loading to which this bridge is subjected:

"Bridge No. 55.2 is located in one of our most important main lines and carries more than its share of special heavy-duty cars. Our records show that we have moved an average of 16,000,000 gross tons per year over this bridge. A check of typical days in recent months shows that we are operating 6 passenger trains and about 15 freight trains daily over this line, with a gross tonnage per day of about 65,000."

(Text continued on page 681)

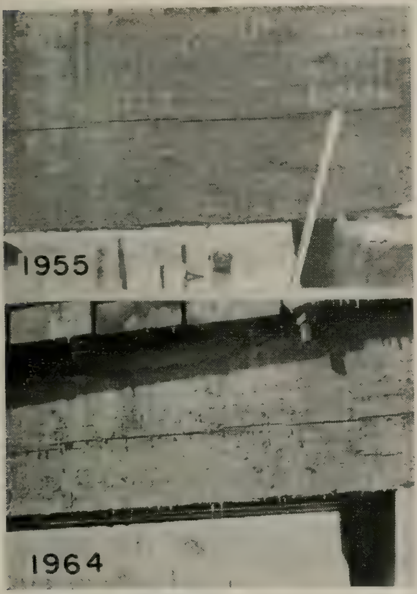


Fig. 3—Solid-sawn stringer.

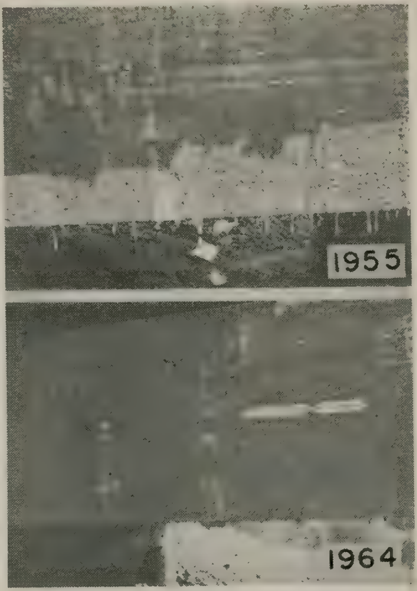


Fig. 4—Laminated stringer.

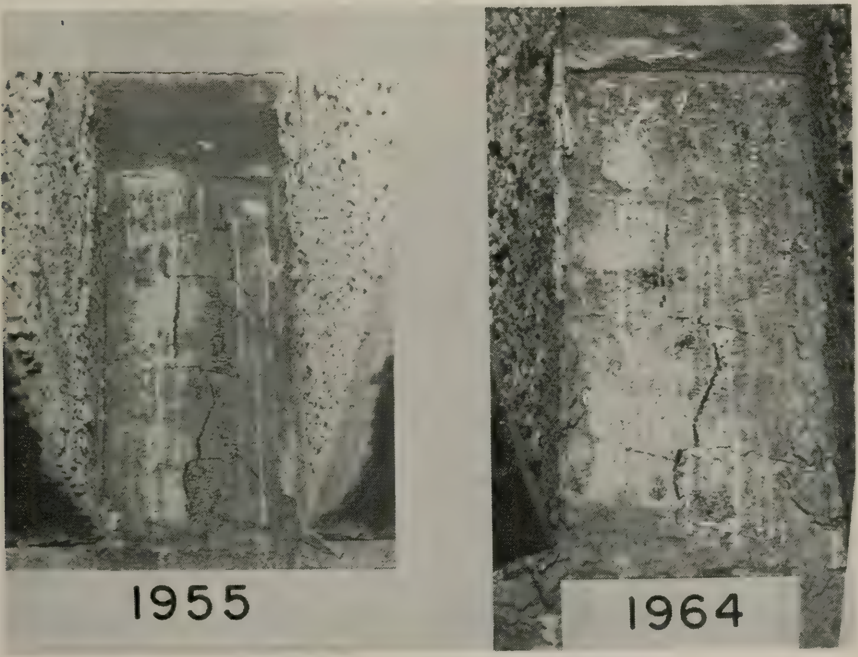


Fig. 5—End views of glu-lam stringer.

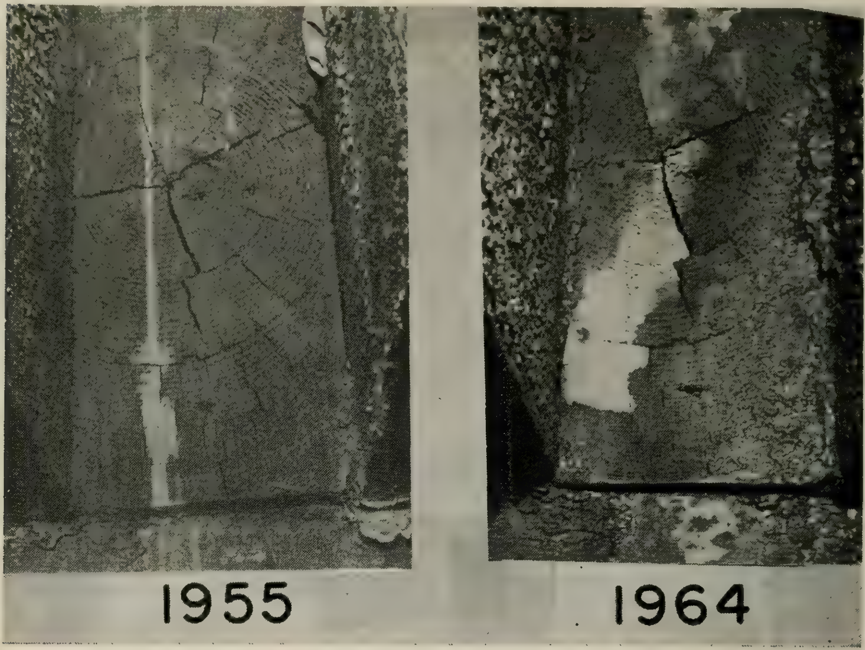


Fig. 6—East end of solid-sawn stringer between glu-lam stringers 2 and 3.

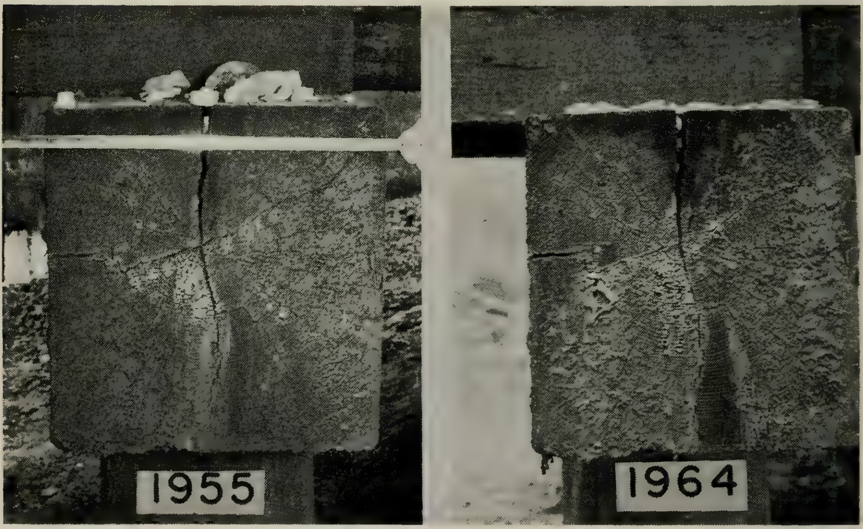


Fig. 7—Solid-sawn cap, South end.

Southern Railway

Th glu-lam members were installed in an open-deck framed trestle on an industry spur (Fig. 8), oriented north and south by compass direction. They comprise the posts and caps of four of the bents and the stringers in two of the spans. The posts are 12 by 12 in and the caps 12 by 14 in. in cross section, and the stringers (6 in all) are 8 in by 16 in, 27 ft long, 3 per chord and continuous over a bent. All the other framed bents and stringers, and all sills, are of solid-sawn material.

Except for the outer laminations of the caps, which are of oak, the lumber is southern pine. A resorcinal-type synthetic resin glue was used for all edge joints and scarf joints. A phenol-formaldehyde synthetic resin glue was used for the laminations. After gluing the members were surfaced to size, bored and framed according to plans and then treated. The retention obtained was slightly less than 8 lb per cu ft of an 80–20 creosote-coal tar solution. For detailed information on fabrication and treatment see AREA Proceedings, Vol. 48, page 382.

In general, it can be said that the glu-lam members were relatively free of large checks and splits, whereas certain of the solid-sawn members had numerous large checks.

The presence of large checks in the solid-sawn caps and the absence of them in the glu-lam caps was particularly apparent. In Fig. 9 no checks in the cap are visible. The cap shown in Fig. 10 has small vertical checks throughout the cross section and one larger one in the top oak lamination. As shown in Fig. 11, this cap was similarly checked, but in addition was cracked horizontally at mid-depth at a glue line. This may have been caused by the sway-brace bolt. Except for this one horizontal crack, no other glue line separations were noted in the caps. Considerable radial and circumferential checking is noted in the solid-sawn caps. (See Figs. 12 and 13)

On 5 of the 16 glu-lam posts, no surface checking whatsoever was observed. A typical post is shown in Fig. 14. The other posts had light checking on one or more faces. At the center of one post a ½-in-deep check was noted on one face, and near the ground line of another, a 1-in-deep check was observed. These were in the wood, however, and not along a glue line. There was a heavy surface layer of preservative on all the glu-lam posts.

The solid-sawn posts inspected had deep, wide checks, as shown in Fig. 15. Some were as much as ⅜ in wide. It was noticeable that there was no preservative oil at the surface of these posts.

Only one check was noted in a glu-lam stringer. This was near the top over the bent. A general view of the glu-lam stringer chord is shown in Fig. 16. One large check was observed in a solid-sawn stringer.

(Text continued on page 685)

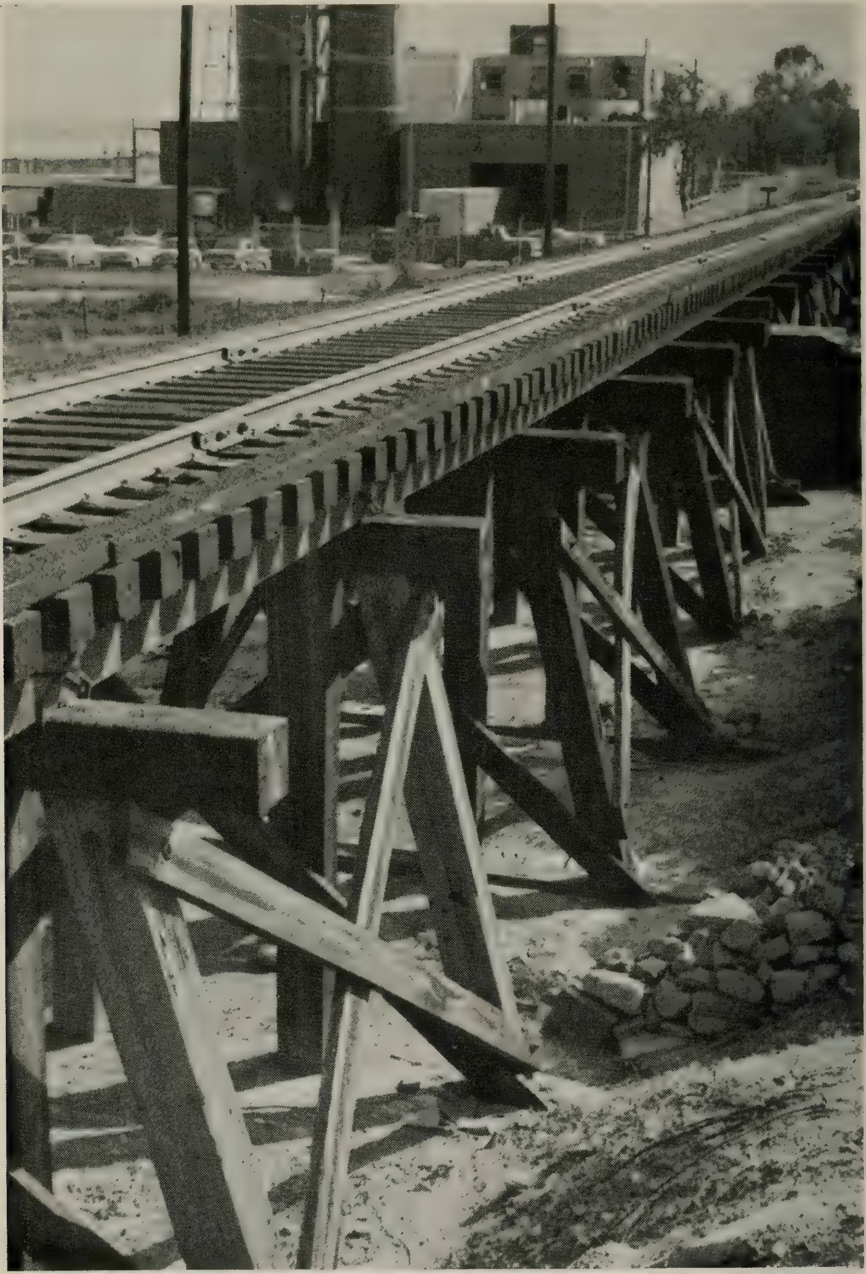


Fig. 8—General view of Southern Railway trestle.

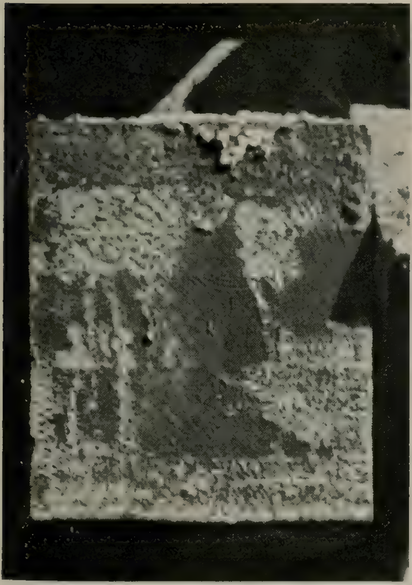


Fig. 9—West end of glu-lam cap, bent 3.

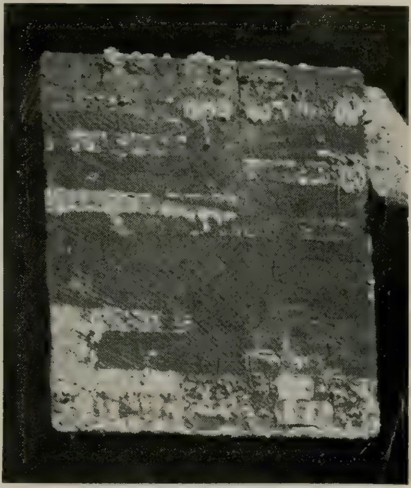


Fig. 10—West end of glu-lam cap, bent 4.

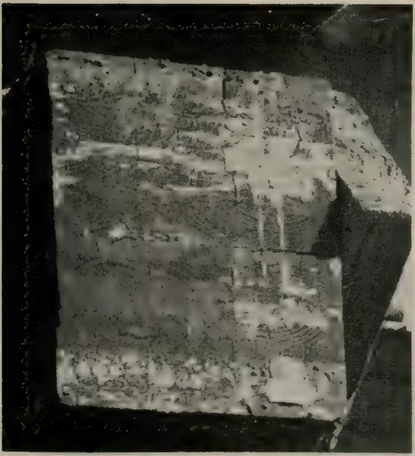


Fig. 11—West end of glu-lam cap, bent 6.

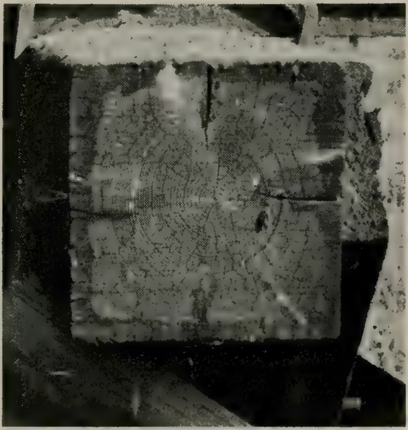


Fig. 12—West end of solid-sawn cap, bent 1.

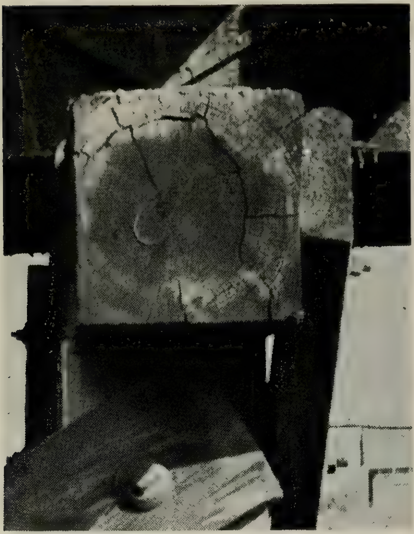


Fig. 13—West end of solid-sawn cap, bent 2.

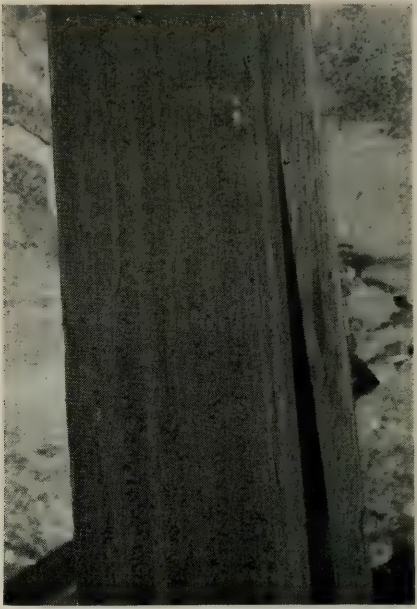


Fig. 14—Typical glu-lam post.

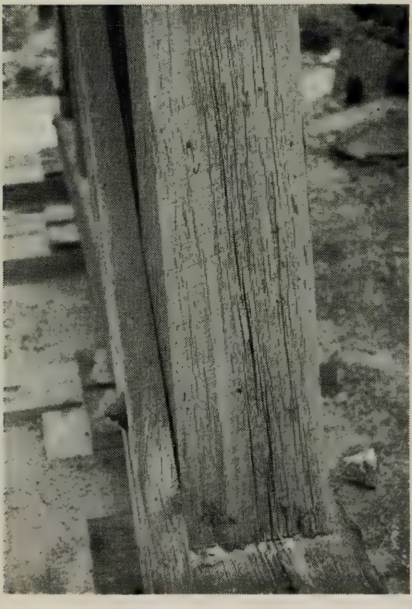


Fig. 15 (left)—Solid-sawn post, bent 7.

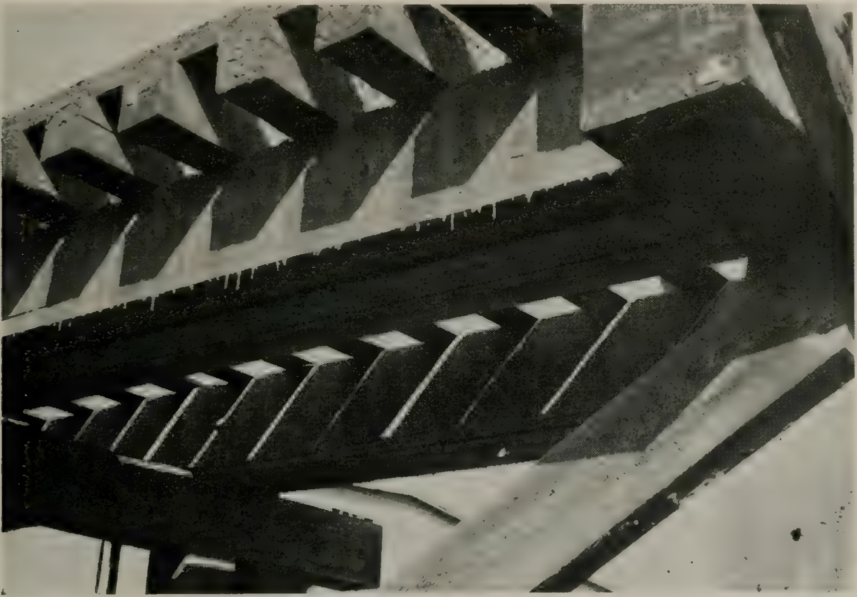


Fig. 16—Glu-lam stringers, span 6.

Southern Pacific Company

Fig. 17 shows the two-panel, ballasted-deck pile trestle No. 643.71, containing the glu-lam test members (stringers and caps). It runs approximately east and west by compass direction, and is located in the arid desert in the vicinity of the Salton Sea in California, at an elevation of 200 ft below sea level. The stringers, 14 in all, are 7¼ in by 17¾ in, 30 ft long. The caps (3 in all) are 13½ in by 14½ in. in cross section.

All the lumber is Douglas fir. A phenol-formaldehyde resin glue was used. The fabricated members were treated with a coal-tar creosote without incising to a final retention between 10 and 12 lb per cu ft. For more information on fabrication and treatment, see AREA Proceedings, Vol. 52, page 429.

All these glu-lam members are relatively free of large checks and splits.

The stringers are arranged in two chords, six in each chord, and two separately as jack stringers, one under each ballast curb. All the stringer surfaces and edges were noticeably dry and splintery. A typical interior stringer is shown in Fig. 18. One small check was noted on each side of the north jack stringer, and on the bottom of stringer No. 1. The south jack stringer had a glue line separation, 2 in deep and 8 in long, at the east end over the cap.

All scarf joints like those shown in Fig. 19 were sound except one, on the bottom of a jack stringer, which has a slight glue line separation.

The only significant checking of the caps appeared to be in the ends, as shown in Figs. 20, 21 and 22. The ends were very heavy with preservative as shown, but the sides were relatively dry. The end of the center cap and the side of the outside stringer are shown.

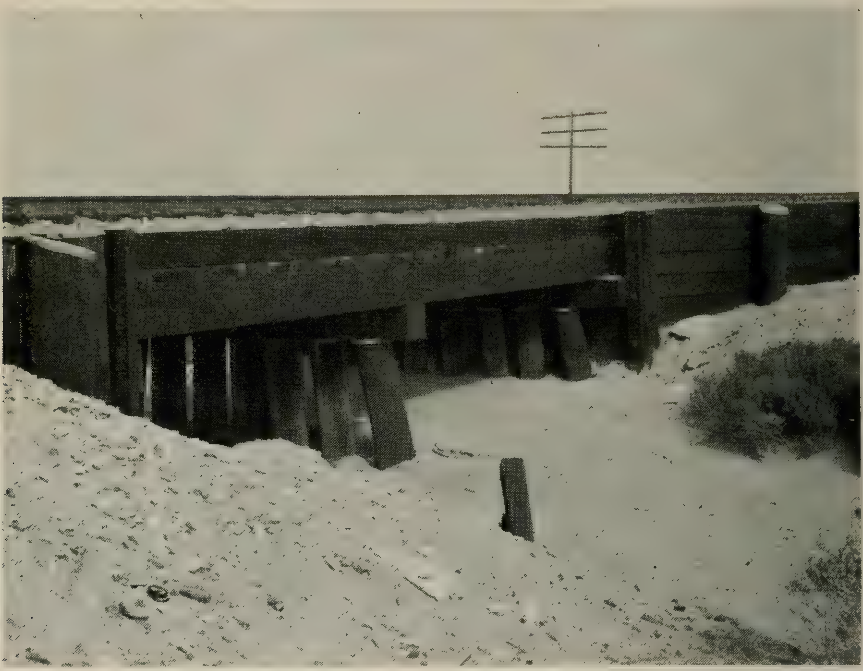


Fig. 17—General view of Southern Pacific Co. trestle.

This bridge carries a very heavy volume of traffic, as indicated by the following data from the engineer of bridges:

"The average tonnage since 1960 over this structure has been as follows:

	Million Gross Tons
1960	33.1
1961	36.1
1962	38.2
1963	39.4
1964	39.4

"The total million gross tons during the 20 years this structure has been in service is 638.7, or an average per year of 31.9."

(Text continued on page 689)

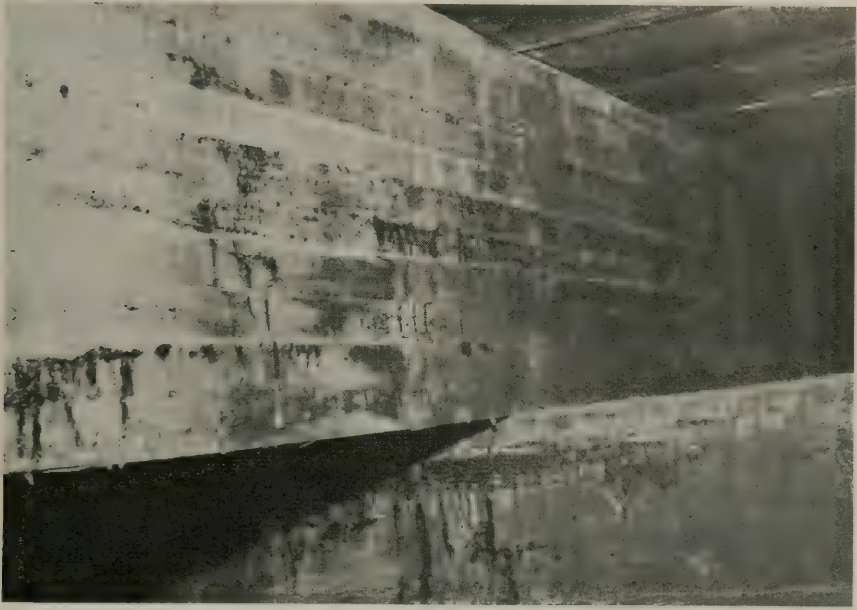


Fig. 18—Interior stringer and center cap—both glu-lam.

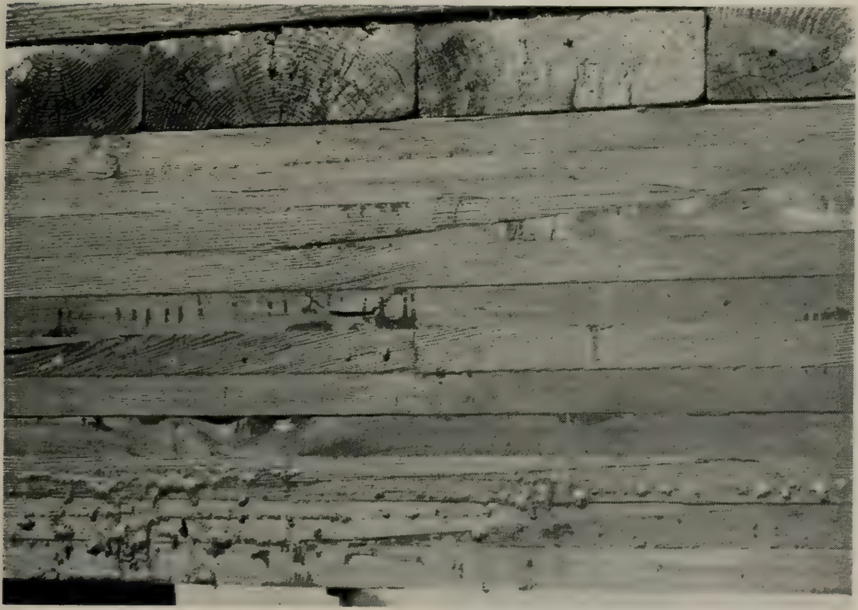


Fig. 19—View of outside stringer, showing scarf joints.

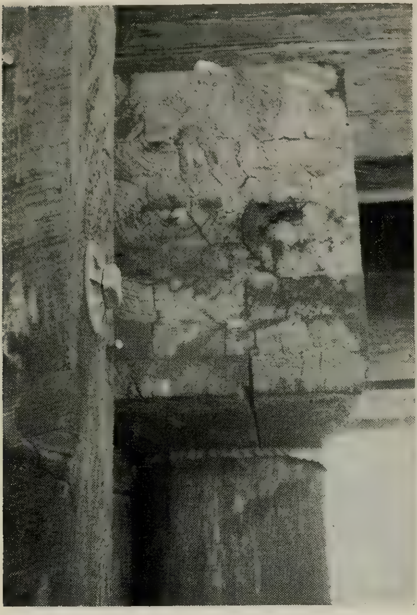


Fig. 20—Glu-lam cap at end bent.

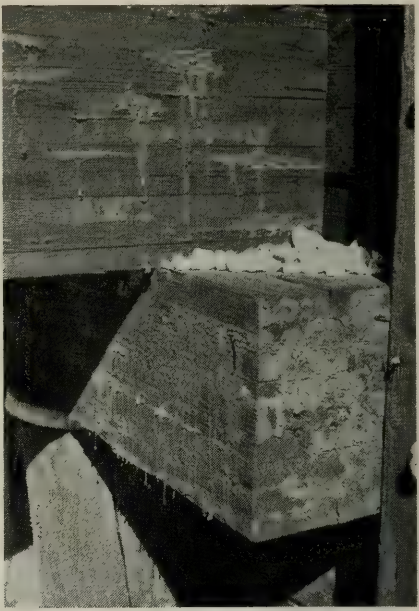


Fig. 21—Glu-lam stringer and cap at end bent.

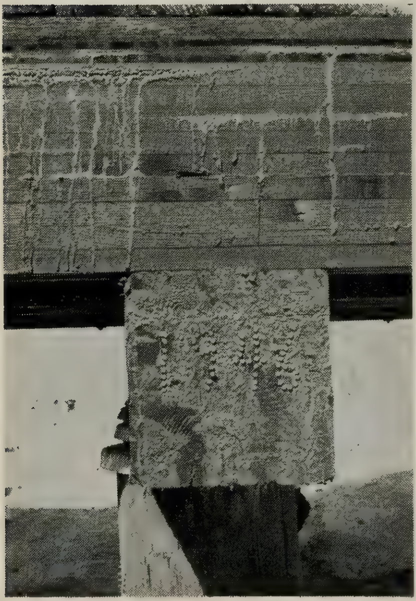


Fig. 22 (left)—Glu-lam stringer and cap at center bent.

Chesapeake & Ohio Railway

The two remaining stringers of the original test installation, shown in Fig. 23, are now in service in bridge No. 18.8 serving the Webb Mining Company at Ferndale, W. Va. They are 7½ in by 16 in, 14 ft long, of Douglas fir lumber, and were glued with a phenol-resorcinal resin. After fabrication they were incised and treated with Minalith. In 1946, these stringers were installed in a bridge at Ameagle, W. Va., but in 1956 they were taken out in good condition and placed in an adjoining mine track trestle. In 1964 they were removed and placed in their present location.

These stringers appeared to be in good condition. Some slight checking was evident and the ends were somewhat battered and split, as shown in Fig. 24, as a result of their being removed and reinstalled at the various locations, but they should give many more years of service.

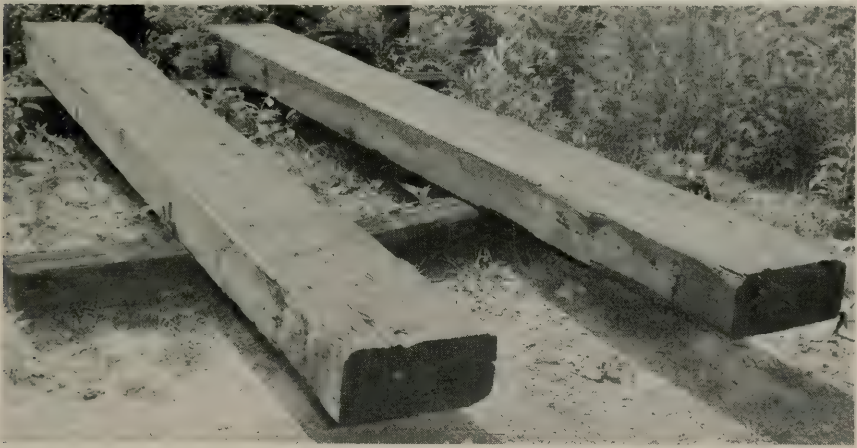


Fig. 23—Two glu-lam stringers removed and later replaced in C&O trestle.

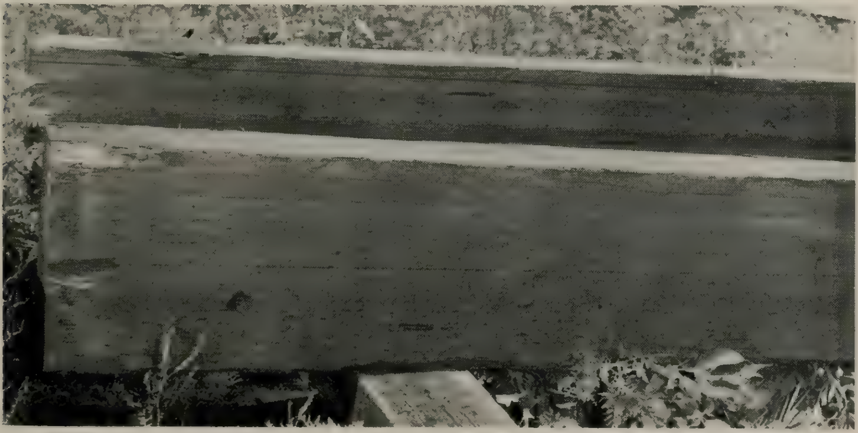


Fig. 24—Another view of the C&O glu-lam stringers.

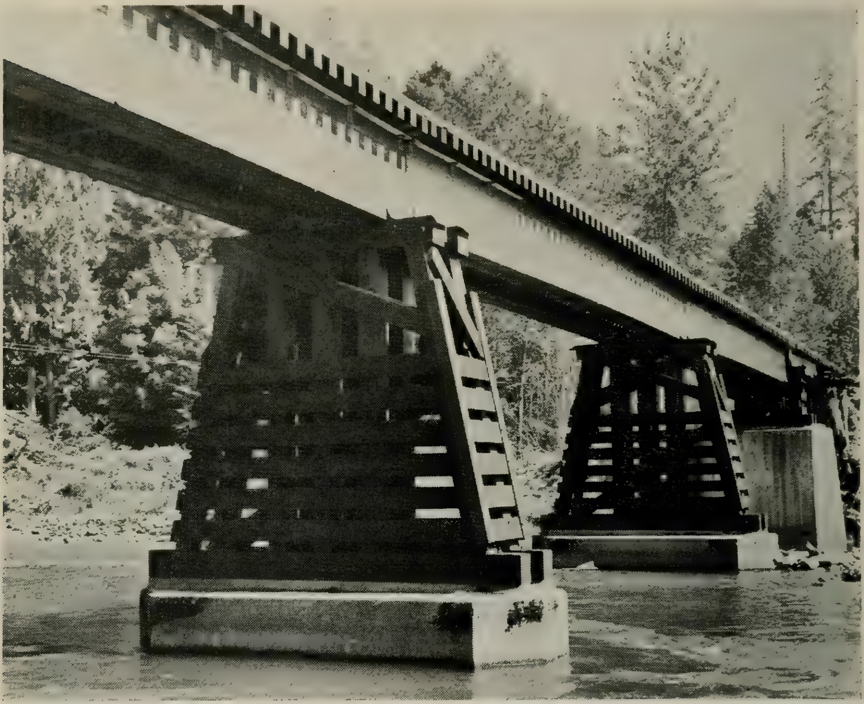


Fig. 25—Weyerhaeuser Timber Co. bridge over Toutle River, Longview, Wash.

The tests installations just described utilize short-span elements, and while these may represent the greatest usage for railroad purposes it must be recognized that glu-lam is also well suited to long-span bridges, as will be illustrated in the following discussion.

In 1955 the Weyerhaeuser Timber Company built the bridge shown in Fig. 25 over the Toutle River near Longview, Wash. It has 60-ft glu-lam girders. Each girder is 12½ in wide and 4 ft 4 in deep, four girders to a span, as shown in the sketch of Fig. 26. This bridge carries logging trains and was designed for Cooper E 50 loading.

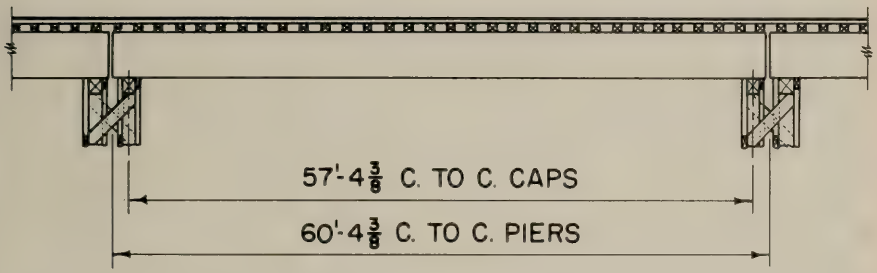
While this span is the longest in this country carrying railroad loading, Canada has two spectacular glu-lam bridges in British Columbia. One of these, built in 1962, contains 132-ft long girders, as shown in the sketch of Fig. 27. The track is supported by 4 of these girders, each nearly 7 ft deep and 20¾ in wide. Another similar bridge near by has 110-ft-long girders. Both of these bridges were designed for E 50 loading.

From the foregoing it is evident that the glu-lam trestles have performed well during the past 20-year period and there is every indication that they have many more serviceable years ahead. It has also been shown that glu-lam is a versatile material and can be used for long span as well as short-span bridges. Now, what about cost?

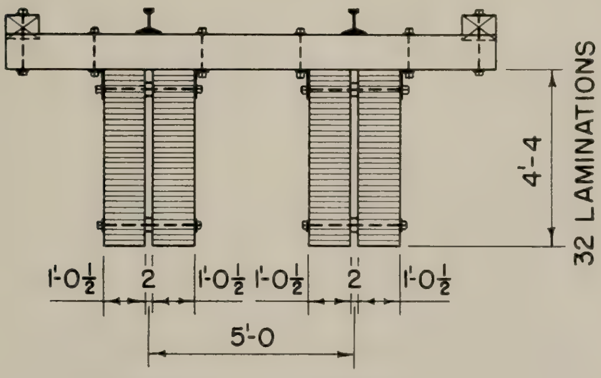
During the past few years, the Research Center has been investigating the strength of glu-lam stringers and has bought full-size Douglas fir and southern pine specimens.

FIG. 26

WEYERHAEUSER TIMBER CO.
GLUED-LAMINATED GIRDER SPAN
LONGVIEW, WASHINGTON



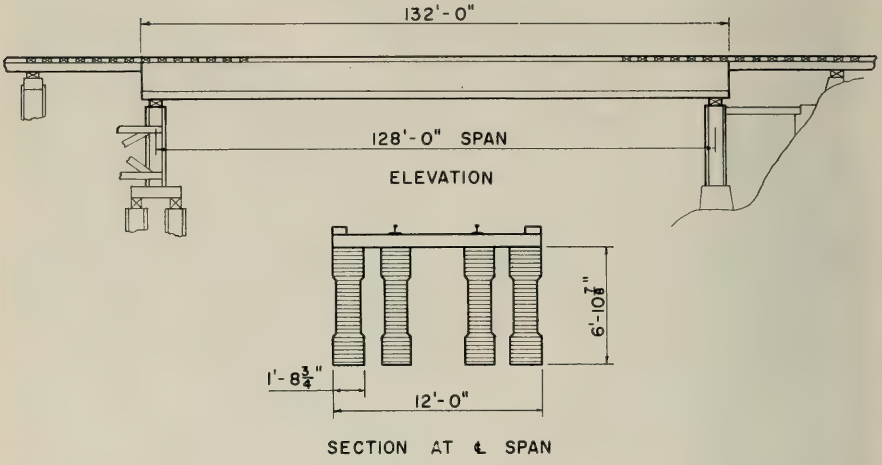
ELEVATION



SECTION AT ℄ SPAN

FIG. 27

CANADIAN FOREST PRODUCTS LIMITED
GROVES CREEK BRIDGE



These were 7 by 16¼ in, 16 ft long. The Douglas fir stringers cost $64.50 each and the southern pine, $56.90 each. In terms of cost per thousand-foot-board measure, this comes to $425 and $375 respectively.

The Santa Fe installed a glu-lam trestle in 1957 as a test installation of its own. This is a 7-panel open-deck pile trestle on a branch line near Kirbeyville, Tex. It contains 6¾- by 16½-in-stringers and 14-in by 15½-in caps on 14-ft panels. The cost of the untreated wood was $391.95 per Mfbm. The Santa Fe, of course, treated the timber with its usual 50–50 creosote–petroleum preservative. Since the cost for untreated solid-sawn stringers was $150 per Mfbm, the road paid extra for the glu-lam. It reported, however, that the cost-in-place was less than for solid-sawn construction because the fabrication was good and all pieces were uniform in dimension, which facilitated erection. Incidentally, the road also reported that these glu-lam elements are still "as good as new."

The above examples indicate that glu-lam lumber for trestle construction *does* cost more than solid-sawn lumber. For longer span bridges, however, such as 60 ft, the cost picture is different. For these lengths, solid-sawn members, of course, are out of the question, and the choice must be between glu-lam and other materials, such as steel or concrete.

A glu-lam span of 60 ft designed for E 72 loading will cost about $11,800. A comparable steel span, which will weigh about 76,000 lb, will cost, at 17 cents a pound, about $13,500, including painting. The open timber deck and end bearings are not included as they will not be greatly different for the two types. This indicates that glu-lam construction for the longer spans is competitive with steel.

Glued-laminated construction has shown excellent performance in the past 20 years and has many recognized advantages. However, like all engineering materials, economy will dictate the extent of its use. I am confident, though, that where it is used, it will prove to be a serviceable and satisfactory material for many years. Thank you. [Applause]

Chairman Daniels: Thank you, Mr. Drew, for an exceptionally fine presentation. Please accept the thanks of this committee.

Mr. Vice President, this completes Committee 7's presentation.

Vice President Johnston: Thank you, Mr. Daniels, for a most interesting and informative group of reports. Your committee has done its usual exemplary job of work. We know that you and the members will continue to keep us informed on the current developments in your field.

We extend our thanks and appreciation to you, Mr. Drew, for your interesting discussion on glu-lam structural components. It seems that you AAR research engineers always give outstanding presentations. We thank you for your continued help and support of our committee work. It is indispensible.

Mr. Daniels, thank you again. Your committe is now excused with the thanks of the Association. [Applause]

Discussion on Cooperative Relations with Universities

[For report, see Bulletin 590, pages 325–338]

Vice President Johnston: The final report of this morning session will be that of Committee 24—Cooperative Relations with Universities, the chairman of which is J. F. Davison, assistant to chief engineer, Canadian National Railways, Montreal, Que. Mr. Davison, will you and the members of your committee please come to the platform, utilizing the overflow chairs as necessary. The subcommittee chairmen making reports should sit in the places closest to the podium.

Mr. Davison, you may proceed with the business at hand.

Chairman J. F. Davison: Mr. Vice President, members and guests:

It is with regret that Committee 24 must record the death of S. R. (Sam) Hursh, who made so many friends during his long career with the Pennsylvania Railroad. I am sure there are many here today to whom the memoir appearing as part of our committee report will serve as a reminder of a deep personal loss. I think it is fitting to repeat here the citation which he received in 1960 from Pennsylvania State University:

> "To Samuel R. Hursh, for the several outstanding achievements that have marked his long career with a major industrial enterprise; for the development of valuable labor-saving railroad equipment and machinery; and for his devotion to and service in the cause of the American economic system."

Time permitted a memoir to Mr. Hursh being prepared for publication in Bulletin 590, but time has not permitted suitable reference to the sudden death of R. W. Middleton on February 26. Mr. Middleton served the Milwaukee in various capacities, and at the time of his death was office engineer at Chicago. He had been a member of AREA since 1946 and an active supporter of Committee 24. A suitable memoir will be prepared for presentation in a future Bulletin.

Before reporting on its assignments, it is usual for Committee 24 to report briefly on ASEE activities. The 72nd Annual Meeting of the American Society for Engineering Education was held June 22–26 on the campus of the University of Maine at Orono, Maine. Unfortunately, it was not possible to arrange for representation at this meeting nor at the College-Industry Conference which preceded it in February. For this reason there is no specific report on ASEE activities; but for those who wish additional information, full reports are contained in the *Journal of Engineering Education*.

In proceeding with the report of Committee 24's activities, I would point out that pages 325–338, incl. of Bulletin 590 contains the record of progress on the seven assignments.

Assignment 1—Stimulate Greater Appreciation on the Part of Railway Management of (a) the Importance of Bringing into the Service Selected Graduates of Colleges and Universities, and (b) the Necessity of Providing Adequate Means for Recruiting Such Graduates and Retaining Them in Service

CHAIRMAN DAVISON: This is an important assignment which is fulfilled in many ways not listed in our subcommittee activities. The informal activities include personal contact with railway management personnel, and the efforts of Committee 24 would be greatly assisted if each member of AREA were to take every opportunity offered to convince his own company management of the wisdom of this course.

The formal portion of this assignment is currently being undertaken in two parts. First, the analysis of the questionnaire completed by some 2000 engineering graduates; second, a survey to establish a comparison between railway and other industry salary levels for engineers. Progress is being made on both portions of this assignment, and results will be submitted in subsequent reports. The chairman of this subcommittee is A. V. Johnston, chief engineer, Canadian National Railways, who is substituting for President Burris at the moment.

Assignment 2—Stimulate Among College and University Students a Greater Interest in the Science of Transportation and Its Importance in the National Economic Structure by (a) Cooperation With and Contributing to the Activities of Student Organizations in Colleges and Universities, and (b) Presenting to Students and Their Counselors a Positive Approach to the Attractive and Interesting Features of the Railroad Industry and the Advantages of Choosing Railroading as a Career

CHAIRMAN DAVISON: Professor B. B. Lewis, Purdue University, is chairman of Subcommittee 2, and I should like to ask him to present his report at this time.

PROFESSOR B. B. LEWIS: Your committee, with the cooperation of the railway industry, AREA members, and the secretary's office, has continued furnishing speakers to student organizations at various universities. During the past year 18 talks were given at 11 universities.

Other activities under this assignment included inspections of railroad property by students and the provision by railroads of exhibits at university functions. The Pictorial Railroad Exhibit prepared through the efforts of Committee 24 and the executive secretary's office was on display at the Oregon Museum of Science and Industry at Portland, Ore., an open house at the University of Illinois, and at the Transportation Conference at the Michigan Technological University.

E. W. Hodgkins, executive secretary, advises that he mailed a letter to 63 selected schools advising them of the availability of railroad speakers and of the Pictorial Railroad Exhibit. Another letter was mailed to 250 colleges and universities in the United States and Canada informing them of the availability of the Third Edition of the Engineering Recruiting Brochure.

As of October 1, 1964, there were 51 student affiliates at 21 different colleges and universities.

On behalf of Subcommittee 2, I wish to take this opportunity to thank the railway industry, and the members and officers of the Association for their assistance in this program.

Assignment 3—The Cooperative System of Education, Including Summer Employment in Railway Service

Chairman Davison: Professor W. A. Oliver, University of Illinois, is chairman of this subcommittee, and I should like to ask him to present his report at this time.

Professor W. A. Oliver: The report on Assignment 3 will be found in Bulletin 590, January 1965, page 330.

Committee 24 became actively interested in the summer employment of engineering students by the railroads in 1948–49, but it was 1959 before the present program was begun. The program consists essentially of sending a questionnaire concerning their summer employment needs to the chief engineering and maintenance officers of the railroads in the U. S., Canada, and Mexico. The replies are tabulated by the subcommittee and sent to the office of the Association's executive secretary where they are reproduced and sent to the deans, department heads, and placement officers of some 125 engineering colleges with the request that they bring these opportunities for summer employment with the railroads to the attention of their students.

As would be expected, the engineering colleges have been very cooperative, and requests for the continuation of the service and favorable comments have come from a number of them.

There has in general been about a 50 percent return of the questionnaire from the railroads. Not all of these offer summer employment through this Committee 24 project. But the return has been large enough and encouraging enough that the committee has continued the assignment from year to year. Furthermore, it should be mentioned that many railroads have for a long period of time employed college students for the summer months by direct recruiting from colleges located adjacent to their properties. It is also known that many young men have, as a result of the experience obtained through such summer employment, accepted permanent employment with the railroads subsequent to graduation.

Committee 24 takes this opportunity to thank the railroads for the interest they have shown in this project and requests their continuing cooperation.

Assignment 5—Ways in Which Railroads Can Cooperate with Universities in Developing Research, Including the Revision of "Suggested Topics for Study and Research on Railroad Subjects"

Chairman Davison: This subcommittee has initiated a system of Student Research Grants to assist students writing theses or reports on railway-oriented subjects. Although the grants are limited to a maximum of $100 each, their purpose is to make both the student and his professor aware of the railway industry and its problems. A total of $1000 was provided in the 1964 budget for these grants and a similar amount has been made available for 1965.

H. E. Hurst, division engineer, Chicago, Milwaukee, St. Paul & Pacific Railway, is chairman of this subcommittee. Will Mr. Hurst please rise.

Assignment 7—Stimulate an Interest by College and University Staff Members in Current Railroad Problems and Practices, Including AREA Membership

Chairman Davison: Professor W. W. Hay, University of Illinois, is chairman of this subcommittee, and I should like to ask him to present his report at this time.

Professor W. W. Hay: Assignment 7 poses the responsibility of examining and determining ways in which to interest college and university faculty in current railroad problems and practices. The report in full is contained on pages 333 through 338 of AREA Bulletin 590, January 1965.

One of the ways proposed to acquaint academic personnel with the problems and practices of the railroad industry is to make available to them a challenging summer program by employment as consultants, by assignment to specific projects within their area of specialization, or in other ways spelled out in the report. The faculty member will, in turn, take back to the campus an enthusiasm for and an understanding of the railroads' problems and potentialities which he will communicate to his students and colleagues. Another advantage lies in making academic personnel more industry-minded, giving them professional alternatives to purely research activities.

This study reviews some of the possibilities and problems in such a program. It points out the successful use of similar programs by practically all other types of industry and by government agencies.

A conclusion is that the railroads are missing a significant opportunity to create a sympathetic attitude toward their industry among college and university faculty and staff.

This is a progress report presented as information.

Assignment 6—Procedures for Orienting and Developing Newly Employed Engineering Personnel

Assignment 8—Current Changes in Engineering Education and Their Implications Regarding Employment of Future Graduates by the Railroad Industry

Chairman Davison: These two assignments are interrelated; and as the chairmen both live on the West Coast, they are developing a joint approach and will report their findings at a subsequent meeting. Professor V. J. Roggeveen, Stanford University, is chairman of Subcommittee 6, and J. F. Pearce, office engineer, Western Pacific Railroad, is chairman of Subcommittee 8, but unfortunately neither of these gentlemen were able to attend this convention.

Chairman Davison (continuing): Mr. President, this concludes the formal portion of Committee 24's report.

As announced on the program, we have a special feature as part of our presentation. Our speaker is W. L. Everitt, dean of the College of Engineering, University of Illinois, and I am sure there are few men with a more imposing list of honors and qualifications. He started his professional career following graduation as an electrical engineer from Cornell University in 1922 and has spent most of his career in engineering education. In this pursuit he has earned his M.S. at the University of Michigan (1926), his Ph.D. at Ohio State University (1933) and was granted his D.Eng. (honorary) by Bradley University in 1959.

Dean Everitt's interests have not been limited to the academic, however, as attested by a long list of activities, involving many government boards and committees. Many of these activities involve the Department of Defense, both before and after World War II. During this latter period he served as director, Operational Research Staff, Office of Chief Signal Officer, U. S. Army.

Our guest has also taken an active part in a number of technical societies. To name a few, he has been a member of the American Institute of Electrical Engineers since 1925 and was awarded its Medal for Electrical Engineering Education in 1957. He has also been a member of the Institute of Radio Engineers since 1925, became president of that organization in 1945, and was awarded its Medal of Honor in 1954.

More recently he was awarded the Mervin J. Kelly Telecommunications Medal in 1963 by the Institute of Electrical and Electronics Engineers.

Within the field of engineering education, Dean Everitt has served with distinction also. He served the American Society for Engineering Education in various capacities, culminating in the presidency in 1956–57, and was awarded the Lamme Medal in 1957. He has also served as president of the Engineers' Council for Professional Development for the years 1958–61.

Only the addition of some railroad experience could make his accomplishments more impressive to an audience such as we have here today. Dean Everitt has chosen the title, "What Price Glamour" for his address today, and it is with pleasure that I now ask him to come forward.

What Price Glamour

By W. L. EVERITT

Dean of Engineering, University of Illinois at Urbana

The University of Illinois has had a long and close relationship with the railway industry. For many years we had an identified Railway Engineering Department with majors in three areas: civil, electrical, and mechanical engineering. We now have many more student affiliates of the American Railway Engineering Association on our campus than any other institution, and we are particularly proud of the involvement of Professor Hay, both nationally and internationally, in the many aspects of railway engineering.

From the beginnings of the railway industry, engineers and engineering have played a prominent part in its development and management. It is doubtful if it could exist without them. In considering the relation of engineering to this or any other field, let us consider briefly what engineering is, how it functions. In the public mind, and particularly in the public press, there has been much confusion about the difference between the functions of the engineer and of the scientist. I, personally, feel that it is important to recognize the difference. To my mind, the scientific function is primarily to answer questions of the type: "If you have a certain combination, what will happen?", while the engineering function is to answer questions of the type, "If you want something to happen, what do you put together to make it happen?" Von Karman highlighted the difference well when he said, "The scientists explore what is and engineers create what has never been." Speaking as an engineer, I think one of the major problems before the American Railway Engineering Association may well be: what do you want to happen?—are you looking forward to the creation of what has never been, or are you only longing to return to a nostaglic image of which used to be?

No engineer can proceed properly unless he sets objectives and goals. He must do this with a realistic appraisal of his resources, what he has to work with. This is equally true for an engineering team, an association, or an engineering-oriented industry. We consider it a function of a university to help individuals and groups attain their objectives, assuming that such objectives are consonant with our own function, purposes, and capabilities. This needs cooperation on the part of all concerned.

The major product of the university is our supply of educated graduates. This is where we serve society, including the industrial sector, best. The other product is the flow of new ideas resulting from the work of both faculty and students. We should examine the utilization of these two products when we consider cooperative relations between the railroad industry and universities.

There is great competition for the product of our engineering colleges. Last year, for example, 345 of the graduates of the College of Engineering at Illinois went immediately into industry out of a total of 743; of the remainder 243 went on to graduate school; 63 went into the military service to fulfill their ROTC contracts; 19 returned to their foreign homes. To recruit the 345 graduates, over 2500 representatives from 819 companies visited our campus. The figures for the number of companies count General Electric and the Bell System, each as one company. The average salary offered was $615 per month, which, incidentally, was increased to $628 for the graduates from our recent February class. You can see that there was less than one-half a man available for each industrial company which visited us, and the wisdom of Solomon could not provide an equitable distribution. Naturally, there were many disappointed companies.

Year after year, when we ask students to identify the relative concerns involved in choosing the company or industry they select, you may be interested to know that among the reasons salary comes out fourth. Interest in the nature and promise of the work always wins first place.

In recent years, I have frequently heard slurring remarks about "glamour industries" from representatives of industrial concerns who have had difficulty in recruiting our seniors or graduate students. I looked up the word "glamour" in Webster. It defines this word as "an elusive, mysteriously exciting, and often illusory attractiveness that stirs the imagination and appeals to a taste for the unconventional or unexpected—a strangely alluring atmosphere of romantic enchantment."

I do not think I have to specify exactly what are currently referred to as the glamour industries. They normally mean electronics, including computers and control systems, and aerospace. About one-quarter of last June's graduates went into electronically based industries and one-eighth into the aerospace group.

In the 1920's, which I can remember, although some of you probably can not, there was a well known play and later a movie entitled "What Price—Glory." This was a war-based play which examined the values of war and the price exacted from its participants. It concluded this type of "Glory" was not worth the price. The title I chose for this talk is somewhat analogous to that of the play, but I propose that "glamour" is not entirely to be despised and may have values which should not be lightly dismissed. When I was a boy, I am sure that, if the term were used, railroading would have been considered a glamour industry. The whistle of the railroad train and its identification with travel to far away places was indeed "mysteriously exciting," "stirred the imagination," and "appealed to a taste for the unexpected." It held a "strangely alluring atmosphere of romantic enchantment."

The lifeblood of any industry, the fundamental ingredients whose flow and replenishment determine its vitality of growth and resistance to wear and tear or even decay, are *men* and *money*. And the most important of these two are men—men of vigor and imagination, who not only work hard but effectively, who have ideas which enable the industry to adapt itself to changing times and conditions. I insist that, whether one calls it "glamour" or not, only those industries whose activities "stir the imagination" and "appeal to a taste for the unexpected" can hope to attract the most vigorous minds from among our young people under the present competitive conditions. Unless the supply of new personnel entering any industry is equal to or better than that of earlier decades that industry cannot maintain itself but is foredoomed to decline. Hence, it behooves any industry to consider carefully how it appeals, what is GQ, or "Glamour Quotient" actually is among two publics—the public which supplies its flow of personnel and the public which supplies its customers and flow of capital. Obviously these two publics overlap.

It is not my function today to discuss your relations with the general public—except to remark that unless these relations are considered good—it is very difficult to attract and hold an important subdivision of that group—those who must be your engineering and management leaders of the future. I cannot refrain from remarking that many of us feel that you have neglected the passenger section of your operations and we wonder whether this is wise. I recognize that "freight pays the freight." But your passenger trains and stations are your "showcase" to the nation. Many people draw conclusions, rightly or wrongly, from their experiences with that service.

If one may refer to a story of air travel in a group like this, I will tell you about a plane in the mid-Atlantic whose loudspeaker announced: "We are now flying at 35,000 feet. If you will look out the right window you will notice that two engines are on fire—on the left you may see that the engines have been stopped. If you look directly below, you will see a yellow life raft with six dots on it. The dots are the pilot, the copilot, the flight engineer, the navigator, and two hostesses. This is a recording."

Sometimes I feel the management of the railroads have left their passengers as much as the crew of the airplane in the story.

But today I am suggesting that it is appropriate that we consider the question of what your "Glamour Quotient" is among the college graduates—and particularly the engineering graduates. Is it good, or even adequate? And whether it is good or not—can it be made better? Do you think it is really important that it be better? First—how have you been doing?

Not too long ago the railroads could attract as many young engineers as they wished, and they could call upon the best. In 1909, the 15 graduates from the Railway Department represented 10 percent of the total engineering class. Before the Railway Engineering Department was discontinued in 1947 because of lack of demand, we graduated 298 from that curriculum. But in the 9-year period from February 1956 to June 1964, only 11 out of 3553 graduates of the College of Engineering accepted employment with the railroads, or 0.3 percent. I am sure that some of you will say this is because professors do not properly present the railroad story, graduates turn away from the railroads because they are improperly informed. In much the same way, engineering colleges are criticized by another public utility group, the electrical power industry. Conferences have been convened and papers written by distinguished authors on their problem. Unquestionably, one of the major problems in developing cooperative relations between the railroad industry and the universities is the matter of public relations, and the two utility groups are similar in this respect.

In no previous period in the history of mankind has change been so rapid, so dynamic, or so explosive as our present era. This applies to scientific and technological growth on the one hand and to changing social relations on the other. It is inevitable that individuals, groups, or industries either take leadership in guiding social change or they become victims of the developments in which they are immersed. Whether individuals or groups lead, or are classed as victims, depends upon the depth, the clarity, and the boldness of the thinking characteristic of the group involved. In some situations it may even not be so important as to what things are as to what the public thinks they are. Your reputation may be as important as your character. I feel sure a significant limitation on the forward progress of the railroads is its present lack of attraction to the brightest minds among our younger men. In doing some homework for this discussion, I read statistics on decline in freight loadings and passenger traffic. What is not so subject to expression in figures is the answer to the question, "What is happening to your personnel recruitment?"

You heard me cite that among our June student body one-third were planning on going to graduate school. This percentage is steadily increasing. There is no question but that this group is drawn from our brightest minds. For example, 56 out of the 72 students in the upper 20 percent of the June class went on to graduate programs. Yet at a previous meeting of your Committee 24 held on our campus, it was stated that the railroad industry considered it had no need for students of the graduate type. If you believe this, you inevitably accept the corollary that you do not need your share of the best brains. This produces what we now refer to as "feedback," meaning that because so very few graduate students are employed in the railroad industry, the railroads develop little skill or knowledge in how to use such people, so do not attract them to their staffs, and in turn do not provide the atmosphere of a ferment of ideas characteristic of putting brainy people together. The purpose of modern graduate training is to teach students to be creative, and to be knowledgeable in new ideas and concepts at the very border of man's forward movement. It is also a common experience that, when one meets new or difficult situations, if one puts bright people on the job, irrespective of what their experience may have been in the past, they tend to come up with original suggestions and proposals. For those who think that modern graduate training is unnecessary, let me recall that not so very long ago the railroad industry felt that it probably did not even need engineering graduates for its engineering work, but could depend upon training on the job. If one looks back over the past 200 years, one can identify the golden age of almost every industry with the period when they were growing, when their leaders did not have the experience of how things were done before but had to work out continuously new and unique solutions for unusual problems. Someone has said, "When you're green you're growing, when you're ripe you'll soon wither." While I recognize that under government relation and strong unionization an industry is not entirely the master of its own fate, yet the picture, correct or incorrect, that most students have of the railroad industry is that great emphasis is placed on seniority, not only among the craftsmen but also among the professionals, of learning by doing—that is, learning how to do something the same way it has been done before, of playing it safe not only with passenger lives but also with procedures, regulations, and concepts.

Let us now turn to the second product of the university—ideas. Engineering colleges have undergone dramatic changes in curricula and activities since the war. There is now quite a different climate. Some find the changes distasteful, and this is true even among members of our faculty, but others find a sense of excitement and involvement in the affairs of the world and a desire to contribute to these affairs in a constructive manners which is new and stimulating. In first-rate institutions this includes a commitment to creative endeavor on the part of faculty and advanced students, and increasingly on the part of undergraduate students. These creative endeavors are of various types, but most commonly can be included under the designation of "research." The term "research" has undoubtedly been used to cover a variety of sins as well as virtues and involves a wide spectrum of activities. These research activities have been supported for the most part by various agencies of government and so do not adequately include all the engineering fields in an equitable manner. Nevertheless, there can be no question that these activities have an influence on the interests of the students. When they see their professors and the associated graduate students involved in the exciting and creative engineering programs now operating on the campus they may, at times, gain a slanted view of the relative emphasis in the world outside. Yet one has to face life as it exists. Speaking from my own professional experience, I can say that a great deal of the interest of students in the electronic and communication field has developed because this is an area where research has been supported on the campus from a variety of sources. This industry is also one that is noted for company support of research. When immersed in an environment where new ideas in the field are being developed, students are attracted to and gain a knowledge of these fields and an understanding of the sources of the advances and exciting new developments. This makes it relatively easy for visiting recruiters from these industries to attract our graduates. At the same time it keeps our faculties, who are working in these areas, keen and alert so that they, in turn, appeal to the students as individuals whom they would like to emulate.

There is a startling difference between the attention of the railway and the communication industries to the significance of research in their respective fields. I understand that last year the gross operating revenue of the railroads was $9,560,000,000. I find in the September–October 1964 issue of *AREA News* that the proposed 1965 Engineering Division Program and Budget Request involves a total of $473,300. I checked the 1963 annual report of the AT&T Company and found a surprisingly close total for operating revenue, namely $9,568,961,000. Out of this revenue the AT&T Company contributed $66,794,000 to the support of the Bell Telephone Laboratories. Is it any wonder that the research agency of the AT&T Company, and, in fact, its subsidiary companies, have relatively little difficulty in recruiting some of the best engineering minds coming out of our universities? Furthermore, they not only seek the output of our graduate schools but, in our Electrical Engineering Department the Bell Laboratories are now supporting five of their employees full time, with full salary and payment of all tuition charges, while they work towards their Master's Degree.

I recognize that the budget figure by no means represents all of the support of research on the part of the railroads, and that the purchase of equipment in turn supports research by the suppliers and that a few railroads engage in research on their own properties. However, the figures I quoted for the contribution of the operating companies of the Bell System does not represent the total support of the Bell Laboratories; a comparable sum is provided from the manufacturing subsidiary, the Western Electric Company. I read in the report of the Committee on Science and Technology in the Railway Industry, which was appointed by the National Academy of Sciences, which reported to the Secretary of Commerce in August, 1963, the recommendation that a rapid rise in funds should be made available through the Association of American Railroads to the Railway Research Institute. The proposal was that, within five years, support should be established and increased from one to ten million dollars per annum. Implementation of this and the other recommendations of that report would go far to correct the situation I have been discussing.

We have had on our campus, from time to time, sponsored research supported by the railway industry. But support has fallen away since the war, particularly percentage-wise. Yet the famous research of Professor Moore on our campus on the means of avoiding transverse fissures in rails has been estimated to have saved the railroad industry something of the order of a hundred million dollars.

I feel certain that there are many areas in the operation of the railroads which could appeal to our best students. And I feel it would be of considerable importance to your industry to pay particular attention to how you can present your opportunities. Engineering today might be divided into the general fields of the processing of materials, the processing of energy, the processing of information, and the utilization of these three processes in organizing an operating system. There is developing a major interest in Systems Analysis as a university discipline. Related to this is the emerging field of

Operations Research. Another growing interest on the campus is the development of interdisciplinary approaches which utilize the skills of a variety of specialists in unified approaches to real situations in the world about us. This is a type of integration in which the railways have had much experience, upon which their business is based. Such integration involves not only engineering but also the problems of economics and human environmental control. Both new and old sources of energy will be needed for your prime movers, new materials will be required for new environments and which are cheaper or better for old environments, and new approaches to the processing of information to provide control under completely new conditions will be required so that vehicles will be where they should be at the times you want them to be there. I can assure you that the universities have skills and interests which would be of advantage to the railways if they would but employ them to an extent much greater than they have in the past. Such facilities and abilities are being employed by many other industries, notably the aerospace and electronics industries. However, the involvement of the universities in such efforts would also require moneys which have not been available to us in the past; money in not insignificant sums but still small in comparisons with the capital involved. Furthermore, I am not proposing such financial commitments as something to be subtracted from your net income, but rather as an investment that should return many fold as did the research of Professor Moore. We have people like Professor Hay who can help you establish relationships and programs, if you are interested and really mean business. [Applause]

CHAIRMAN DAVISON: It is my privilege to thank Dean Everitt on behalf of Committee 24 for the provocative message he has brought us today. Had Dean Everitt been present at our opening session to hear the keynote address given by R. R. Manion, it would have surprised him how well the two messages complement each other without any prearrangement. Yesterday Mr. Manion spoke of the industry's future in terms of traffic opportunities and technology requirements. Today Dean Everitt has spoken of the technological requirements in terms of the people needed to achieve it. Yesterday Mr. Manion spoke of the need for a group of "idea mn" or planners. Today Dean Everitt has reflected the engineering educator's reaction to the rather small practical steps which the industry is taking toward the fulfillment of this need.

The conclusion appears obvious. The opportunities are there for the railways to grasp, but unless proper attention is given to getting properly qualified people who can recognize and take advantage of modern technology, these opportunities can be lost by default. May I extend to you, Dean Everitt, the thanks of Committee 24 for your excellent presentation.

Mr. Vice President, this concludes the report of Committee 24.

VICE PRESIDENT JOHNSTON: Thank you, Mr. Davison, for the fine reports that you have submitted. Thank you, Dean Everitt, for that dynamic and inspiring talk. It is my personal hope that once again the railroad industry will be as attractive to engineering graduates as it was in the past.

I won't attempt to comment on the wealth of information and statistics that Dean Everitt has presented to us, but I am sure Committee 24, and speaking for myself particularly, is going to use some of it in their endeavors to attract the right type of graduates to the railways, and of course subsequently some membership in AREA; that goes without saying. I think we have much to offer these young men in the way of professional development and attainments. Thank you again, Dean Everitt, for your splendid address.

Also, I want to convey my thanks to all of the professors who are active in the Association, and special thanks to those taking an active part in the work of Committee 24. We are proud to have so many here today from the University of Illinois. To take nothing away from Professor Lewis, who is a stalwart in the activities of Committee 24, we have heard from three men from the University of Illinois, all of whom have been excellent.

This committee needs and deserves active support from the top-level engineering and maintenance officers of all railroads.

Mr. Davison, you and your committee are excused with the thanks of the Association. [Applause]

Vice President Johnston [continuing]: Gentlemen, this completes our morning session. Before I recess the meeting for our Annual Luncheon, I would like to remind you that the afternoon session will reconvene here in this room at 2 pm. The first report on the program of the afternoon session will be delivered by Committee 16—Economics of Railway Location and Operation. It will include an illustrated address by Professor C. L. Miller, head, Department of Civil Engineering, Massachusetts Institute of Technology, on the subject, "New Developments in Engineering Use of Computers."

The meeting is now recessed for the Annual Luncheon in the Banquet Room. Please assemble there as quickly as possible.

[The meeting recessed at 12:15 pm.]

Annual Luncheon

Wednesday, March 24, 1965

[The Annual Luncheon of the Association was held in the Banquet Room, beginning at 12:15 pm. At the main speaker's table were seated the officers of the Association, several past presidents, and a number of special guests. At a long table immediately in front of the main speaker's table were seated the chairmen of the Association's 22 standing committees. In greeting those at the luncheon, President Burris spoke as follows:]

President Burris: Members of the American Railway Engineering Association and guests: welcome to the Annual Association Luncheon.

Seated here at our speaker's table are your officers and a number of special guests, all of whom will be introduced immediately after your luncheon. At that time also I expect to be able to announce to you the results of our election of officers for the ensuing year. Until then, let's all enjoy our luncheon together.

[Luncheon was served. After the luncheon President Burris spoke as follows:]

President Burris: As President of the American Railway Engineering Association I welcome you here to the Annual Luncheon of our Association. I shall now introduce those at the speaker's table. As your name is called, please stand momentarily. Applause should be withheld until all have been introduced.

[President Burris then introduced those at the speaker's table.]

President Burris (continuing): I shall now recognize the chairmen of our 22 standing committees seated at the long table immediately in front of me. I should not say *introduce* because all of these men are well known to most of you. But I do want to recognize them in appreciation of the service which they render to this Association through the leadership and direction which they give to our committees. Each one should stand as his name is read and remain standing until all have been presented. And again, to conserve time, please withhold your applause until the rest of our chairmen have been presented.

[President Burris then presented those at the chairmen's table, after which he introduced the Annual Luncheon speaker as follows:]

President Burris: Gentlemen, it is my very great pleasure to introduce to you today a colleague and a friend, Gregory DeVine, president of the Chesapeake & Ohio and executive vice president of the Baltimore & Ohio railroads, which are affiliated systems, as you know.

Greg DeVine comes home when he comes to speak to us today. Born in New Jersey, he moved to Chicago as a boy, was educated in Chicago schools, at St. Viator's College in Bourbonnais, Ill., and at the Medill School of Journalism of Northwestern University. His first job was as a police reporter for the Chicago Journal. Later he joined the staff of Black Diamond magazine, and from there entered the coal industry and a successful career in sales.

For 22 years, Greg was with Truax–Traer Coal Company, and a predecessor company, Binkley Coal Company, of which he was president. Before joining C&O he was executive vice president of Peabody Southern Coal and president of St. Louis Sales Company, a Peabody affiliate.

Then, in 1957, Walter Tuohy managed to lure Greg away from the coal industry to become vice president in charge of C&O's coal traffic and development department. He was named senior vice president of the railroad in 1960, executive vice president in 1963 and president in 1964.. Last month he was also named executive vice president of B&O. He is a director of both C&O and B&O.

Last year when Greg was elected president of C&O, one of the Cleveland newspapers said:

"The new C&O president is every inch the leader. A two-fisted competitor, he is also regarded by his associates as kind and humane. He is a fast decision-maker, has a ready wit and is a vigorous salesman. Chessie, the C&O cat, ought to be wide awake under DeVine guidance."

So, heavenly days, gentlemen, here is Greg DeVine.

The Challenge of Change

By GREGORY S. DeVINE

President, Chesapeake & Ohio Railway

Gentlemen, the railway engineer is obsolete.

That's what the evidence shows. In 1965, the track, property, equipment and facilities of our industry represent a net investment of $26 billion dollars. Almost all of that—$20 billion of it—has been spent since World War II for modernization. So, in a single generation, you engineers have created practically a new railroad industry from the ground up. What is there left for you to do?

Let's take roadway maintenance, as an example. Today, my railroad and yours are laying welded rail from moving trains. We maintain track and roadbed with a sophisticated equipment and skilled technicians, instead of pick-and-shovel labor. The savings are tremendous. If my railroad had to maintain its lines at present wage rates and the methods of 20 years ago, costs would be $100 million more than they are. It looks like you have solved the roadway problem.

Twenty-nine-thousand miles of Centralized Traffic Control have been installed since 1946. Against the total of nearly a quarter million miles of American rail lines that doesn't sound important. But those 29,000 miles carry the heaviest traffic on our systems and CTC has given each mile of single track the capacity of a multiple-track line. The railroads would have gone broke if they had to build the additional trackage CTC has created electronically. What more do you have to do?

Engineers turned the Iron Horse out to pasture and revolutionized the industry with diesel motive power. Today's 30,000 diesel locomotives offer the astonishing total of 44 million horsepower. This is equal, in terms of power capability, to all the steam-electric generating plants in 30 states and the District of Columbia. And it is power immediately available. Steam power, for all its advantages, was not. Can you engineers top this achievement?

Half of the railroad industry's 2 million freight cars have been acquired in the last 20 years. Most of them are superior to their predecessors, because you engineers have built into them greater capacity, flexibility, suitability to specific products and protection against heat, cold and impact. You have made them highly desirable, and so they are among the most highly utilized and profit-producing freight cars.

Take just these few examples of your accomplishments. The conclusion seems unmistakable. Your job is well done—but done. Engineers are obsolete.

Now all we have to do is turn everything over to computers and let them run the whole industry from a total operations center. Right?

But wait a minute. *Is* your job all over?

Look around us. While the railroads have been changing, the world we live in has been changing, too. And it has been changing faster than we have.

In fact, all the change we have gone though has only been a prelude to more change. Today we stand at the threshold of an age that bears little resemblance to the times we have known.

Yesterday, two American astronauts orbited the earth for 5 hours. Last week, two Russians did the same thing and one of them, 300 miles in space, blithely stepped outside to stretch his legs. Who would say that our lives will ever be the same?

This year, American industry will spend $6 billion—a little less than a third of what the railroads have spent in 20 years—just for research and development. Just to ask questions. Can you imagine what this investment in risk is going to churn up in the form of new products and new markets?

Take a clue from the last decade. One major company makes half of its money from products that didn't exist ten years ago. A company that concentrated its production on auto tires in 1954 is still making them, but thanks to R&D and diversification, it is also manufacturing rocket and missile components, plastics, furniture and a host of other products. In the decade, its sales have tripled. So have its transportation requirements.

As for the change that's coming, we ain't seen nothing yet.

Between midnight today and 12:01 am tomorrow, the world will add in population the equivalent of another Springfield, Ill.—148,000 persons. That means change, too, because more people will require more things. Until the rest of the world can catch up, Western technology and productivity will have to fill most of those wants and the biggest share of the burden will fall on this nation.

Here at home, America's population 10 years from now is expected to reach 235 million. We will be driving 100 million automobiles. The annual average wage will be $9,525 and the gross national product will soar to $960 billion.

Maybe we won't laugh when we hear stories like the one about the Texan who reported that he lost control of his automobile and smashed into seven other Cadillacs. No one was hurt, however. It happened in his own garage.

These population and industrial explosions are going to require a transportation explosion of equal or greater force.

If the railroads do no more than hold their present share of traffic, by 1975 they can expect to carry one-third more freight than they do now. By 1988 the volume is expected to double.

But railroads are aiming at increasing their share of traffic. If we can, and I have no doubts about it, these awesome forecasts are only minimums.

Are American's railroads going to be able to handle the job asked of them, with their present, modern $26 billion plant?

I don't believe they can. I don't think you believe it, either.

And that means that the engineer's job is far from finished. You aren't obsolete by a long shot. Computers can't take your place. And all because of change.

You are no more outmoded than the jet pilot who was being needled by an associate, a scientist working on a remote-control system for aircraft. "When I get this thing finished," he said, "Your days are numbered."

"I don't think so," said the pilot. "Where else can you get a control package that weighs less than 150 pounds, has five senses, six directions of moveability, is self-lubricating and self-repairing and is produced so readily and willingly by inexperienced labor?"

All change isn't necessarily good change. Even good change puts us under a lot of pressure. A Washington columnist reports that he overheard one government official say to another: "I'm getting so accustomed to being tense, that when I'm calm, I'm nervous." On the other hand, there can't be any progress without change.

Look at the past ten years again. Economists call the years from 1955 to 1964 the best decade in America's history. It was also the one most characterized by radical change, but it pushed employment up 12 percent, and purchasing power up by 19 percent and personal annual savings by 86 percent.

We are far more mobile than we were ten years ago. If you came here from Cleveland, as I did, then you know you can fly here in less time than it took you to get from Public Square to Cleveland–Hopkins Airport, check in and board the plane.

In 1965 your chances of staying healthy and living longer are better than ever. And if something is wrong with you, it can be discovered earlier and cured more quickly. Some diseases have been all but eliminated.

You can stay warmer in winter and cooler in summer and it costs you less. You have a wider choice of entertainment and leisure and cultural activities. Maybe you engineers don't have time to enjoy them all, but that's what you get for being in the business.

No, this changed world, even with all the problems it presents, isn't a bad one at all.

For one thing, it keeps engineers from being obsolete. We need you to help us make the most of change, to help us do more than meet change, to anticipate it, to welcome it, to overcome and master it and put it to work for us.

This is the only way to stay on top. In the last 50 years, the list of the biggest 100 business organizations in America has altered mightily. Some of the original companies are still on the list, but many more have vanished and there are plenty of newcomers. It is provable that those who survived from the beginning are the companies that have adapted consistently to change. The newcomers are those who were able to fill needs that existing companies could not. Those who fell from the ranks were the ones unable, or unwilling, to change.

What do railroads have to do to keep up with change and its hastening pace? To make it to the top and stay there?

As a salesman, I think it is most important that we become more attuned to the customer and his wishes than ever before. Let's get it out of our heads once and for all that we are in the business of running trains and building track. Our business is selling service. We have to do everything we can to attract customers to use it.

Our customers can give us lessons. A few years ago, the Electric Fan and Blanket Department of General Electric changed its name to the Home Care and Comfort Department. Everybody laughed. But the Home Care and Comfort people had the last laugh because the change in name triggered a change in attitude. People saw that they were not in the business of producing and getting rid of fans and blankets. They were in the business of anticipating what the public will be interested in buying that will make the home more comfortable and easier to take care of.

My own company has found out it pays to look at things from the customer's point of view. I'm sure your railroads have, too. Our engineers designed a new flatcar at little cost that can load and unload tanks and armored vehicles more cheaply and quickly than trucks could. The cars, plus our people's attitude, won us a half million dollars of business.

New train schedules we worked out for one company get his raw materials to him in half the time it used to take. That has gained for us 100 percent of his business. We used to get only part of it.

This leads us into another challenge of change. We must make greater use of marketing—the science of selling. Many railroads are organizing their marketing services along the lines of their customers. Just as a manufacturer has a manager to supervise the making and selling of each major product, so railroads can profit by putting concentrated attention on specific commodities they transport—a product line manager for iron and steel traffic, for example. If we assign special equipment to a product service, why not get smarter and assign special men and talent, too?

One more challenge is computerization, an opportunity literally begging for full exploitation. Computers are already doing yeoman duty for railroads, like keeping payrolls and tracing cars. However, their great, and largely untapped, potential lies in their ability to provide vital information, up-to-date and in volume, on which management may base quick and successful business decisions. We need to develop this potential even faster.

Computers are becoming amazingly responsive to human command. There was a report recently about the advanced computer that was delivered to the Pentagon. A five-star general put the first question to it. "Will there be war or peace?" he asked.

The computer flashed, blinked, buzzed and said, "Yes."

"Yes?" roared the general. "Yes . . . what?"

The computer blinked, buzzed and then barked: "Yes, *sir!*"

More than anything else, railroads are challenged by change to expand their planning. Like many another railroad, C&O and B&O are putting extra stress on this element. We have set up a joint Planning Department under the direction of its own vice president and a planning board. This is no ivory-tower group. It is a good balance of theorists and experienced operating and engineering people. They work as a team on a variety of projects, some short-range and others long-range enough to be in the blue-sky department. We expect the department's work to begin paying off this year in terms of millions of dollars, through economies as well as an improved ability to do a job of transportation.

This is the basic reason why planning is so important. Planning is the route by which we find the better way. And the better way is most always the low-cost way. Railroads, despite the recent improvement in their total net income, have a long way to go before they achieve real profitability. Cost reduction, combined with traffic expansion, is the answer.

In our planning, we cannot afford to overlook the most valuable ingredient for success—human talent, ingenuity and enthusiasm. A Chinese proverb says: "If you plant for a year, plant rice. If you plant for ten years, plant trees. If you plant for a hundred years, educate men." The railroad industry's recruiting and training programs now must furnish the technical leadership we will require tomorrow. And while they learn, the refreshing viewpoint and lively thinking of these young fellows can be most valuable.

A friend of mine who has his own engineering company and has done imaginative things in the material handling field, once asked a group of college job candidates this question: "What would be the fastest way to unload an ore boat?"

One young fellow said: "Turn it upside down and shake it."

The rest of the group burst into laughter, but my friend cut them short and said: "Wait a minute. I asked for the *fastest* way. This fellow starts thinking big and works down, that's all.

Let's start thinking big. Let's turn the railroad industry upside down—and shake it!

Well, what about you engineers? You aren't salesmen. Or marketing experts. Or transportation specialists. But none of these people can attain their goals without the kind of railroad plant that the new world of change will require. This is where you come in. Pretty soon our customers are going to begin asking for some special orders in innovation. You engineers are going to have to fill those orders . . . orders for innovations like these:

(1) a high-speed roadway that is failure-proof and can be maintained at low-cost. It must be capable of offering 100-mph freight service.

(2) An end at last to the nuisance of terminal delays. Time is money. A 100-mph freight service is no good to your salesmen if it is cancelled out by a 1-mph classification system. You engineers have to give railroad customers a low-cost train-make-up system, with automated switching and train-handling operations. And customers need systems and facilities for speedier loading and unloading of freight cars.

(3) The shippers need cars that are cheap to build, cheap to maintain, never break down, offer perfect protection and can be quickly converted from one kind of service to another.

(4) And ultimately our customers need a low-cost, flexible, universally applicable power unit, that will be maintenance-free.

Five years ago, if these things had been asked for, engineers might well have said, why don't you ask for the moon? Today, the moon is within man's reach and nothing looks impossible anymore.

Railroads can make these demands in good conscience of their engineers. They know how much change you have met and mastered in the past.

If astronauts go somersaulting through space today, they do it only because engineers on the ground put them up there.

If railroads are going to go into orbit, if they are going to crash the barriers of time and cost, it will be you engineers who make it possible. You are being counted on.

Gentlemen, thank you. My congratulations to your president, Fred Burris, on an outstanding meeting. It has been a privilege to be with you today. May all the achievements in your future be as great as those in your past. And don't ever let anyone tell you that you are obsolete. [Applause]

President Burris: Thank you, Mr. DeVine, for your most interesting and informative address. One of the main purposes of the AREA is to keep the railroad industry up to date as far as engineering and maintenance matters are concerned and your address on "The Challenge of Change" for the railroads is very timely and appropriate.

Knowing what a busy schedule you have, I want to express my personal appreciation, and the appreciation of the Association, to you for taking the time to attend our convention and bring us this splendid address.

President Burris (continuing): During the course of our luncheon, as I expected, there was presented to me, by J. E. Wiggins, Jr., office engineer, Southern Railway System, and Chairman of our Tellers Committee, an official copy of the Report of the Tellers, giving the results of our 1965 Election of Officers. I hold this report in my hand, and I should like to read the names of those whom you have selected to direct the overall policies of our Association for the coming year. As I read their names, I would appreciate their standing and remaining standing until the last of the names on the list have been read. I know it will be difficult for you to refrain from applause as each name is read, but I shall appreciate your doing so in the interest of conserving time.

[President Burris then read the names of the newly elected officers and directors, continuing as follows:]

President Burris: I should now like to read the names of the five elected members of the Nominating Committee, who, together with the five most recent living past presidents of our Association, will constitute the Nominating Committee as a whole for the 1966 election. As I read the names of these men, I shall appreciate their standing and remaining standing. Again, please withhold your applause.

[President Burris then read the names, continuing as follows:]

President Burris: Our new officers will be installed at the Closing Business Session of our Convention, which we expect will get underway at 11:20 tomorrow morning, and be completed by 12 noon. I hope that many of you will be present at that ceremony.

Before adjourning this luncheon, I would like to remind you that our Afternoon Session will convene immediately in the Lakeside Room. We have an outstanding program ahead of us this afternoon, which includes the reports of three of our committees—two of them with special features—so I ask that you assemble promptly. The Luncheon is now adjourned.

Afternoon Session, March 24, 1965

[The meeting reconvened at 2:15 pm, President T. F. Burris presiding.

Discussion on Economics of Railway Location and Operation

[For report, see Bulletin 588, pages 143–151]

President Burris: The first committee scheduled to report at this session is Committee 16—Economics of Railway Location and Operation. The chairman of this important committee is T. D. Wofford, Jr., assistant to chief engineer, Illinois Central Railroad, Chicago.

Since Mr. Wofford and the members of his Committee are already on the platform, I shall turn the microphone over to him without further comment, except to remind you that if you have comments or questions from the floor, please state your name and railroad or other connection.

Mr. Wofford, will you begin.

Chairman T. D. Wofford: Mr. President, members of the Association and guests:

Before presenting our report, Committee 16 wishes to express its sorrow at the death of Charles Blackman, retired chief engineer of the Louisville & Nashville Railroad, and Member Emeritus of our committee. Mr. Blackman died on March 22, 1964, at the age of 83. A memoir has been prepared and will be published in the Proceedings.

MEMOIR

Charles Henry Blackman

On March 22, 1964, death claimed Charles Henry Blackman, retired chief engineer of the Louisville & Nashville Railroad and a former chairman of Committee 16, American Railway Engineering Association.

Mr. Blackman was born in Nashville, Tenn. on September 6, 1881, and spent most of his early years on the family farm on Hardscuffle Lane, about two miles east of Brentwood, Tenn. He studied civil engineering at Vanderbilt University and while there worked as chainman and rodman on location surveys for the Tennessee Central Railroad during a portion of 1899 and 1900.

He entered the service of the L&N on May 13, 1901, as a rodman on the Louisville Division, subsequently serving as instrumentman on the Birmingham Division and as draftsman in the chief engineer's office at Louisville.

On October 15, 1904, Mr. Blackman was appointed assistant engineer on the Pensacola Division, returning to the chief engineer's office at Louisville in that capacity on March 1, 1906. He next went to Birmingham as resident engineer of construction on May 1, 1907, subsequently serving as the assistant engineer at Louisville prior to his appointment as principal assistant engineer on October 1, 1914. He was promoted to chief engineer on July 1, 1941.

As chief engineer, Mr. Blackman headed the Railroad's engineering department during a decade of heightened and intensive construction activity. Highlights of his incumbency were the construction of much branch-line trackage in both Eastern and Western Kentucky; of the two-mile-long, reinforced-concrete approach to the Henderson Bridge; and of Dent Yard; the improvement of DeCoursey Yard; the relocation of considerable trackage in West Tennessee, resulting from the creation of Kentucky Lake; and a multi-million dollar program of bridge modernization and improvement. The increased dieselization of the road's motive power also created many problems for Mr. Blackman and his forces in providing for the diesels and the longer and heavier trains which resulted from their operation.

Mr. Blackman joined the AREA in 1913 and was a member of various committees before serving as chairman of Committee 16 from 1948 to 1950. He became a Life Member of AREA in 1948 and was elected Member Emeritus of Committee 16 in 1954. He was a member of the American Society of Civil Engineers, organized its Kentucky Section and was its first secretary. He was also a member and past president of the Engineers and Architects Club of Louisville.

He retired from the service of the L&N on September 1, 1951, and established a small consultant engineering firm in Louisville. In late 1952 he was one of three members of a World Bank Study Commission to Syria with the duty of determining whether a proposed railroad project in Syria was qualified for a World Bank Loan.

Mr. Blackman was revered by all those with whom he worked, and one who made outstanding contributions in his work. He was an able railroad man, a fine engineer, a good citizen and a loyal friend.

J. W. Barriger
Fred N. Nye
R. L. Milner

Chairman Wofford: The committee also wishes to express its sorrow at the death of Member Emeritus H. F. Schryver on February 7, 1965.

Committee 16 has eight current assignments. Reports on the progress of each of these assignments have been published on pages 143–151 of Bulletin 588. Advance reports on two of our assignments were published earlier in Bulletin 587 on pages 1–58.

The assignments undertaken by Committee 16 are dynamic and challenging. The progress reports being made this year are a credit to the subcommittee charimen and members who have worked faithfully.

It is not my intention to take up each of the committee reports in detail. We wish to reserve your time and attention for the special feature that will follow shortly.

Assignment 2—Study of Methods of Analyzing the Economics of Railway Engineering Projects Designed Primarily to Improve the Quality of Transportation Service

Chairman Wofford: The report on our Assignment 2 is recommended to those of you interested in this area. Subcommittee 2 is directed by T. D. Kern, assistant to chief engineer, Illinois Central Railroad, whom I shall ask to stand and be recognized.

Assignment 3—Determination of Maintenance of Way Expense Variation with Various Traffic Volumes and Effect of Using Such Variations, in Terms of Equated Mileage or Other Derived Factors, for Allocation of Available Funds to Maintenance of Way, Collaborating with Committees 11 and 22

Chairman Wofford: A brief progress report is being made on Assignment 3. This assignment is one of the most difficult which our committee has. Subcommittee 3 has been under the direction of L. E. Ward, senior system industrial engineer, Pennsylvania Railroad, whom I shall ask to stand and be recognized. Mr. Ward has recently been named vice chairman of Committee 16, and H. B. Christianson, Jr., director, Industrial Engineering Department, Missouri Pacific Railroad, is assuming the chairmanship of Subcommittee 3. I should like to recognize Mr. Christianson at this time.

Assignment 5—Engineering Methods of Reducing Time of Freight Cars Between Loading and Unloading Points, Collaborating with Car Service Division, AAR, Communication and Signal Section, AAR, Operating–Transportation Division, AAR, and American Association of Railroad Superintendents

Chairman Wofford: A report on Assignment 5, relating to information systems and control techniques designed for the purpose of expediting freight car movements, is in the process of preparation. Subcommittee 5 is under the direction of W. J. Dixon, general manager, Industrial Engineering, B&O and C&O, whom I shall ask to stand and be recognized.

Assignment 6—Features of Economic and Engineering Interest in the Study, Design, Construction and Operation of New Railway Line Projects, or Major Line Relocations, Proposed, In Progress or Recently Completed

Chairman Wofford: I am sure that many of you were interested in reading the very fine description of the construction of the Great Slave Lake Railway in Canada, by J. L. Charles, presented as a report on Assignment 6. Subcommittee 6 is under the direction of H. L. Woldridge, assistant chief engineer—planning and scheduling, Frisco Railway.

Assignment 7—Application of Industrial Engineering Functions to the Railway Industry

Chairman Wofford: Those of you who have an interest in the potential applications of industrial engineering will especialy want to review the report on Assignment 7 concerning a study of a freight car repair facility. Subcommittee 7 is under the direction of G. S. Sowers, assistant director, Industrial Engineering Division, Missouri Pacific Railroad, whom I shall ask to stand be recognized.

Assignment 8—Effects of Innovation on the Economics of Railway Location and Operation

Chairman Wofford: Under Assignment 8 the subcommittee is preparing a report on new operational and engineering concepts that are being studied and on innovations that offer promise in meeting future competitive situations by reducing cost and improving service. Subcommittee 8 is under the direction of M. B. Miller, division engineer, Pennsylvania Railroad, whom I shall ask to stand and be recognized.

Chairman Wofford (continuing): Committee 16 is very pleased to have been able to make arrangements for a computer demonstration during this Convention. At this demonstration you will be able to see at firsthand the "shared-time" concept in action, using several programs of interest to engineers. If you have not taken the time to stop by Room 14 for a few minutes, let me encourage you to do so at either 3 or 4 pm today. The demonstration is well worth your time, and this afternoon will be your last chance.

Our committee has published in the Bulletin two papers relating to potential application of electronic computers. I shall ask L. P. Diamond, assistant engineer—research, Chesapeake & Ohio Railway, to comment briefly on these papers.

L. P. Diamond: In our progress reports published in the recent Bulletins we attempt to point the way to the future. First, we say that, in the future, the primary aid to efficient performance of the railroad engineering function will be the automatic computer.

Second, various specific computer applications to typical engineering problems are outlined in Prof. Miller's paper in Bulletin 587 and Mr. Sinkoff's paper in Bulletin 588.

Chief among the depicted newer techniques particularly useful to the engineer, are problem-oriented computer languages such as COGO and STRESS and open time-sharing computer systems.

More important, however, the point being made is that understanding of the specialized character of the engineering function emphasizes the necessity of developing more powerful computer systems for engineers as contrasted to those available for business purposes. The power lies in removing the communications barriers between the professional engineer and the automatic computer.

Chairman Wofford: At this time I should like to introduce A. S. Lang, director of data systems, New York Central System and Vice Chairman of Subcommittee 1, who will introduce our honored guest.

A. S. Lang: Thank you, Mr. Chairman.

It is a particular pleasure for me to be asked to introduce our speaker this afternoon on behalf of our committee, because for many years, particularly during the time I was on the faculty at MIT, I was a close associate of Professor C. L. Miller and worked with him on a great many things.

Charlie Miller has both his undergraduate and graduate degrees in civil engineering from MIT. Subsequent to taking his undergraduate degree he worked for a number of years for one of the large (at one time the largest) civil engineering firms in this country, Michael Baker, Jr., where he was instrumental in moving that firm into the use of computers for engineering work in an era when this was just beginning to get started in this country.

After leaving Michael Baker, Jr., he came back to MIT as a member of the faculty, where he first was involved in the teaching of surveying, a subject which he, probably more than anyone else in civil engineering education, was responsible for working a complete revolution in.

Starting from his work in surveying, where early in the game he began to exploit the potential of electronic computers which were still quite new back in 1955 and 1956, he went into the development of an entirely new set of concepts about how one goes about the engineering process. This led him to the development of the user-oriented computer languages that Mr. Diamond mentioned a moment ago, COGO being the foremost among them, and from there into even more esoteric (by the lights of most of us who went to school even a few years ago) uses of the computer for engineering work.

I think you are going to find, if you look back 10 or 20 years from now, that the kind of work that Charlie Miller started at MIT and that others have been engaged in in other universities and in engineering organizations will have in fact worked a complete revolution in the way we go about our business as engineers.

It is a great pleasure for me to be able to introduce Professor C. L. Miller, who is now head of the Civil Engineering Department at MIT, who is going to talk to us this afternoon on the subject, "New Developments in Engineering Use of Computers." Charlie Miller.

New Developments in Engineering Use of Computers

By PROFESSOR C. L. MILLER

Head, Department of Civil Engineering, Massachusetts Institute of Technology

We are going to be talking about communications in many senses of the word here this afternoon. Let me say first, however, how much we have appreciated the tremendous interest shown in the demonstrations that were run yesterday and this morning. However, I must apologize to those who showed up this morning, since we did not have a live show. The situation we are dealing with runs something like this:

We are like a family living in a house that is not quite finished. The contractor still has work to do, and keeps bringing crews in to finish the job. In operating a large, complicated, time-sharing system, we are using what the contractor in a sense still has in his hands. You were very patient with us yesterday, and today the contractor brought some crews in to change over some of his previous construction, and he takes priority; so we have one machine that is down while we make systems changes on it, and another one down while some actual hardware changes are being made on it.

This is the price we pay for going ahead and using a new system, a new capability, even before it is finished. We feel this is very important, because the earlier we as engineers get our hands-on experience in using one of these systems the better, because then we can influence its ultimate form. If we wait until the people building the new systems have them all completed, then have them sort of dumped in our laps, it is too late for us to have an influence on how they work and what they do. So, during the period of two or three years that we are in right now, we are in on it with both feet and all fingers, using these experimental time-sharing systems even though they are very much in the early development stage and are still being built, as witness the situation today.

The area of research and development we are concerned with is aimed at trying to bring the computer to you, literally. If we do our job right, then every individual in this room should be able to work quite directly with a computer, with not more than an hour or two of orientation or training, if you will. And that situation is what we are trying to bring about as quickly as we can, because we do not think it should be necessary for you to learn new technology in your profession—a new language, if you will, a whole new set of capabilities—but we should so arrange it that computer systems can interact rather directly with you so that they will understand your language, your way of thinking, and your problems.

This afternoon I should like to report to you rather briefly on four areas of development which we feel stand in line right now with the potential of having rather considerable impact on the engineering use of computers. These are: time-sharing, problem-oriented languages, graphics, and what we might call integrated systems. Let me just describe each of these rather briefly and discuss them as I go along. You will note that these are components of what we were demonstrating yesterday in Room 14.

Time Sharing

The first of these is the matter of time-sharing. In ultimate concept time-sharing is using a computer somewhat as a public utility. We mentioned in one of the sessions yesterday that philosophers like to make an analogy in this field with what has happened in the past 100 years as a result of man's development and utilization of machines that process energy and deliver to him power, amplifying his physical capability for getting his job done and fulfilling his needs. These people attribute much of the advancement of civilization and the development of our industrial society and the economics of it today, to the extent to which we have been able to exploit machines and devices which process energy and deliver power.

These people see a similar kind of revolution over the next 100 years (and perhaps it won't take that long) with machines that process, not energy, but information, and that are the brain or the mind or the mental aspect of man's activities, analogous to his hands and his physical capability in the case of the power machine.

This means, then, that there is no domain of human activity that the computer won't have some role in and some impact on, because all elements of the activity involve more or less, to some degree, great or small, work with information.

Where we stand today with the information machine, however, is roughly where we stood with the power machine when we had steam engines only. In other words, a direct mechanical coupling of the energy-processing machine to the work being done. The next major step will be the development of what is analogous to the electrical distribution system of the country, which make electrical power as accessible to us today as the most convenient outlet or the nearest telephone. The utilities are the backbone of the work in the country today.

In a similar way, one can project the possibility of being able to share a simple processing unit—a computer—in much the same way, analogously speaking at least, as we share a power plant or telephone switch gear, with many, many different users.

Characteristically, what we get from such sharing is convenience of access and the economy of size. The time-sharing label is a rather general one now applied to many different kinds of efforts expended in the direction of making a computer something like a public utility. There are many versions and many efforts under way now designed to provide this convenience of access, and the economy of size that goes with being able to use a central machine.

Of course none of the machines we have today was designed with this kind or mode of usage in mind. As in the case of the machine we are using for the demonstrations here, we can modify existing machines and existing programs to make them work in this general direction, and for experimental purposes work fairly well, but we are doing this primarily to provide experience that will lead to new concepts of machine and program design, and make time sharing really efficient, economical and commercially available.

These various attempts to let many share in a single computer will have great impact on engineering. We might have in the very near future the convenience of local access so that an engineer or engineering organization will have physical accessibility to a machine without having to go to it. The opportunity to interact with a computer for the first time, then, really becomes available.

With the exception of the experience gained by those people who fortunately had a chance some eight or ten years ago to work with a computer sitting right at the console, there is precious little experience today as to what will happen if you can work directly with a computer on engineering problems.

The whole idea of having a computer continuously accessible to you for eight hours a day, as an individual, requires a new kind of thinking or a new way of looking at one's problems. This is a whole new era that we are moving into, and largely the knowledge will come about by experience. Nobody has written any books on it. It has to come from people like yourselves who are working on-line with these machines and gaining this experience. This is a whole new dimension that we can look forward to in the years to come, working directly with computers in a real-time sense.

Problem-Oriented Languages

The second area that closely parallels the time-sharing concept and which we feel in many respects exceeds it in importance, is the area of problem-oriented languages. Our own experience has already clearly indicated that having the console of a very powerful time-shared computer available is a rather thrilling experience but is almost useless unless one has comparable power in what may be generally called software, or the ability to communicate with that machine.

The problem-oriented language concept can be thought of as a goal—the ability of the individual engineer to converse rather directly with the computer, to carry out a dialog with it, if you will, though not in a vocal sense, working quite directly with the machine, not through intermediate people. To do this means that one has to have a very high-level language, and by this we mean a language which you gentlemen speak, the language which you use in talking with each other and with your associates, stating problems, stating their solutions, stating what one would like to know about the problems in a design sense and a response sense.

This means, then, that working with the computer is a lot more than simply typing in data to canned programs on the line. It is awfully hard to get this point across, because we have become so accustomed in the past ten years to working with computers within the context of programs, and going to the library of programs is our mode of communication, if you will. We compute today not with computers but with computer programs, and they are pretty inflexible in many ways. They are tied to a form that one has to fill out.

What we want to switch to is a language that will enable the engineer to sit down at a computer console and state his problem in much the same way he would state it to a fellow engineer—that is, to state the order in which he might want the solution carried out and possibly the method of solution; to continually interact with the computer, telling it what response he wants, observing that response, revising the formulation of the problem, and gradually converging on what he feels in his judgment constitutes a satisfactory solution or satisfactory design.

Such approaches are entirely different from our mode of computer usage today. In fact, it is an interesting paradox that our experience so far has shown that the engineer with no previous computer experience is better off today than the one who has had a lot of computer experience, because the man with a lot of experience has to re-learn, in the sense of developing a whole new mental attitude toward how he uses computers.

In our experience with COGO, for instance, engineering firms and engineering officers who have been using computers the longest represent the smallest users of COGO. Those who have been using it the shortest time represent the biggest users. The field man who has never seen a computer before, but who can walk in with a field book and go to work, is our best friend in terms of implementing new systems today.

One of the crosses we carry on our back is the very name of the machine we are dealing with, "computer," which implies to most people calculations or computations. This will become less and less important, in the sense that the broad major use of computers will be not for calculation, per se, but what might generally be called manipulating information in symbolic form. We have a number of computer activities right now or methods of using a computer which involve essentially no calculation whatsoever.

COGO and STRESS have been early prototypes or "guinea pigs" that have illustrated some of the concepts we are talking about. We feel, at this point in time, that they are only extremely crude beginnings. The new COGO system we are working on right now, which will be initiated in the IBM system 360, is at least 100 times more powerful and sophisticated internally than the present COGO, and more simple externally.

The key summation point with regard to problem-oriented languages and the impact of these new developments on engineering, we feel, relates to the completely different role with respect to the computer that the individual human being—the professional engineer—will play. In the past it has been characteristic of the nature and practice of civil engineering, that we have needed very large numbers of trained people to do rather routine work. We are quite convinced that increasingly in the future we shall need smaller, certainly not larger, numbers of engineers, but these will be more experienced, competent, creative and professional men. These will be the men who will for the first time, I think, really give us the premium of experienced engineering in civil engineering work as opposed to highly trained technicians.

Graphics

So far we have tended to deal with computers primarily in terms of their responding through a punched-card reader or a printer. The human being, particularly the engineer, most effectively and most efficiently deals with information in symbolic, pictorial or graphical form—the sketch, the drawing, the plan, the plot, the model. These are the ways of representing information that we find most convenient, in communicating with ourselves and with our fellow engineers.

Before the advent of computers, people didn't carry columns of tabulated numbers around to show each other as responses to their thinking. They carried drawings, plots or sketches. This clearly, then, is an objective to be realized in bringing the computer to the engineer rather than vice versa.

A rather high priority should be put in our computer systems work on the ability to deal with the computer in a graphical mode. In the next few years I think you will see as one of the most startling and rewarding developments in the computer field—the ability in fact to put information into the computer and get it out in a completely graphical form.

The engineering input–output station of the immediate future in a sense will have to have (because it comes very close to what the engineer ought to have) the ability to deal with graphics.

Integrated Systems

The word "integrated" is a rather unfortunate one today. It is becoming a humpty-dumpty word, like "optimum." We might really go to the ultimate of the humpty-dumpty words and say "an integrated optimum system," and then we would have it all tied together.

Seriously, the idea of this term is to recognize that almost all of the developments to date in the computer field that can bear on the engineering use of computers do represent rather piecemeal developments. There is not yet a very smooth interaction between all these various developments, but the combination of time-sharing, problem-oriented languages, and graphics is important.

When one designs a system at the beginning to exploit to the hilt all these basic technological capabilities, then clearly we should get a much more powerful capability in dealing with engineering problems than to continue to deal with them piecemeal.

In our own case, considering COGO, STRESS and TD, our immediate goal is to be able to say, "We have learned things from all of them; now let's sit down and tie them all together in a very powerful way." This is what we are working on, and we feel that in the immediate future we are really going to turn things around as far as the relationship of the engineer to the computer is concerned.

You might find it of interest to hear about the framework within which the research in our own case is being carried out. Universities rather traditionally have tended to focus on research which has as its end product new knowledge. This is the kind of research that universities, and in fact many other research laboratories, have as their stock in trade—the production of new knowledge. The research may be applied to a particular problem, but it is still concerned with getting a new answer to a situation.

The laboratory we have set up in the MIT Civil Engineering Department, called the Civil Engineering Systems Laboratory, is a little bit unique, we think, in its degree of emphasis upon research aimed, not necessarily at gaining new knowledge but at improving the practice of engineering itself. What we are trying to do is to increase, not how much we know about the real world, but our capabilities for dealing with it.

So, we are very much concerned with advancing the methodology, techniques and procedures for carrying out the practice of civil engineering. That is why we are very interested in and are working very closely with organizations such as yours and with individuals such as you, because the end product of this research is not going to be a report to put on a shelf but a means for implementing your daily work. We are not trying to advance the state of the art in computer technology. We are trying to work with you in advancing the state of our profession.

Thank you very much. [Applause]

Chairman Wofford: Mr. Miller, Committee 16 wishes to express its appreciation to you for bringing us the up-to-date information on a subject of great interest to all railway engineers. I am sure we have all found Professor Miller's comments informative. We also wish to thank him for his assistance in making the computer demonstration possible, and arranging for the services of Bob Efimba and James Champy, from the Massachusetts Institute of Technology, who have assisted in the demonstration.

Mr. President, this concludes the presentation of Committee 16.

President Burris: Thank you, Mr. Wofford, for your continued direction of the work of Committee 16 and the interesting and informative reports your committee always presents. Committee 16 is dealing with some of the most interesting and significant developments in the industry. I know we can count on you and the members of your committee to continue to bring them to our attention.

Professor Miller, the American Railway Engineering Association certainly owes you a debt of gratitude for your remarks this afternoon. You have lucidly and dramatically told us how we can get the most out of this modern technological advancement. Computers certainly are a tool we railway engineers must learn to apply to our operation. We also want to extend our thanks and appreciation to the members of Committee 16 and the International Business Machines Corporation for the computer demonstration in Meeting Room 14. There is no question but that it is one of the highlights of this convention.

Mr. Ward, please accept our best wishes on your promotion to vice chairman of this important committee.

Thank you again, Mr. Wofford, for an outstanding presentation. Your committee is excused with the thanks of the Association. [Applause]

[Vice President Trissal assumed the Chair.]

Discussion on Buildings

[For report, see Bulletin 589, pages 187–223]

Vice President Trissal: The next report will be made by Committee 6—Buildings. The report will be presented by W. C. Humphreys, system architect, New York Central, who is vice chairman of the Committee and who is presenting the report for J. W. Hayes, chairman, who is unable to be present. Mr. Humphreys.

Vice Chairman W. C. Humphreys: Mr. Hayes, the chairman of Committee 6, received word early this week that his father had taken ill, so he made an emergency trip to the West Coast and is thus unable to be with us today. We are sorry he can't be here, but we wish his father a speedy recovery.

I know John has been looking forward to this meeting for some time and to telling you about the work our committee has been doing during the past year. In his absence I shall give you his report. I shall make it as brief as possible so that we will have time for our special feature.

Committee 6 has continued to update its chapter in the AREA Manual, and we are reporting on other timely subjects dealing with new building construction materials and methods. Due to the "information explosion" and accelerated pace at which we are moving, the Manual becomes rapidly obsolete and is a threat to knowledge when this happens. Our next task is to simplify and consolidate its contents wherever possible. We understand that in the near future computers will be set up to accelerate the retrieval of technical and scientific data for finger-tip specification writing. Everybody is complaining that they cannot keep up with modern methods and materials. The Ford Foundation and the University of Minnesota are now doing research in what could be termed a revolution of the building industry.

Assignment 1—Revision of Manual

Vice Chairman Humphreys: Revision of Chapter 6 of the Manual has now been completed by Subcommittee Chairman W. G. Harding, architect, Norfolk & Western Railway, with the inclusion of new data on passenger stations. The report is printed in detail on pages 188–191 of Bulletin 589. This information is to replace, in Chapter 6, the material on pages 6–20–4 and 6–20–5, including Location and Design of Signs for Passenger Stations. Unfortunately Mr. Harding is not here to be recognized.

Mr. President, I move the adoption of the foregoing deletion and additions to the Manual.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 2—Specifications for Railway Buildings

Vice Chairman Humphreys: C. R. Madeley, supervising engineer, Southern Pacific Company, Texas & Louisiana Lines, Houston, Tex., is chairman of Subcommittee 2, which submits a report on portable stations, many of which are now being used. The report appears in Bulletin 589, pages 191–194, incl. Will Mr. Madeley please stand and be recognized. Thank you, Mr. Madeley, for the fine report.

Assignment 3—Use of Synthetic Resins for Adhesives in Connection with Railway Buildings

Vice Chairman Humphreys: When adhesives are accurately proportioned and applied in accordance with recommended practices, they can be useful to the railroad industry. Using structural adhesives now on the market, entire walls can be erected without the benefit of a single nail. Wood strips can be placed directly on concrete, and wood panels can then be glued to the wood strip. Entire walls can be paneled without the use of any nails.

H. A. Shannon, Jr., engineer of buildings, Norfolk & Western Railway, Roanoke, Va., is responsible for the report on the use of synthetic resins for adhesives in connection with railway buildings, published in Bulletin 589, pages 195–198, incl. Mr. Shannon is not here today. He did a good job, and we thank him.

Assignment 4—New Advances in Paint and Coating Products for Railway Buildings

Vice Chairman Humphreys: A. F. Langmeyer, general building inspector, Illinois Central Railway, is chairman of Subcommittee 4. Numerous painting systems using synthetic resins and coatings, such as alkyd resins, latexes, acrylic, epoxy, vinyl alkyd, phenolic, polyester and silicone resins, are now in use. Information on these systems is included in Bulletin 589, pages 199–202.

Will A. F. Langmeyer please stand and be recognized. Thank you, Mr. Langmeyer.

Assignment 5—Prestressed Concrete for Railway Buildings

Vice Chairman Humphreys: W. R. Hyma, assistant engineer, Atchison, Topeka & Santa Fe Railway, Chicago, is chairman of Subcommittee 5, and is responsible for the timely report on prestressed concrete for railway buildings included in Bulletin 589, pages 202–210, incl. Many of the railroads are using prestressed concrete beams, purlins, etc., in building construction, and more use will be made of these materials and methods in the future.

Will W. R. Hyma please stand and be recognized. Thank you, Mr. Hyma, for your excellent work in collaboration with Committee 8.

Assignment 6—Use of Plastic Materials in Railway Buildings

Vice Chairman Humphreys: H. R. Helker, assistant engineer, Missouri Pacific Railroad is chairman of Subcommittee 6. The current report is in Bulletin 589, pages 210–221, incl. Plastics are being used in roof, wall and ceiling systems; also in floors, interior paneling, counters, doors and furniture.

This report deals very briefly with the history and development of a number of plastic materials, and discusses the end products in regard to their use as building materials. The report readily agrees that these new products have a bright future but at this time recommends rigid material control to avoid disappointment. We have included a number of items for the designer to consider when using plastic material. Mr. Helker also is not with us today. We thank him for his hard work and the fine job he has done.

Assignment 7—Curtain Wall Construction for Railway Buildings

Vice Chairman Humphreys: Subcommittee 7 has a report in progress which will be presented next year.

Will R. J. Martens, general architect, Union Pacific Railroad, please stand and be recognized.

Assignment 8—Infra-red Heating

Vice Chairman Humphreys: D. A. Bessey, assistant architect, Chicago, Milwaukee, St. Paul & Pacific Railroad, Chicago, is chairman of Subcommittee 8—Infrared Heating, Collaborating with Committee 18. Bulletin 589, pages 222 and 223, contains his report. Research engineers are continuing the study of electric and gas heaters, and the study will be reported on at some later date.

Will Mr. Bessey please stand and be recognized for a job well done. Thank you, Mr. Bessey.

Assignment 9—"Critical Path Method" for Architects and Engineers in the Railway Building Field

VICE CHAIRMAN HUMPHREYS: I. G. Forbes, engineer—buildings, Illinois Central Railroad, is chairman of Subcommittee 9. Will Mr. Forbes please stand and be recognized. Thank you, Mr. Forbes.

VICE CHAIRMAN HUMPHREYS: The construction industry has recognized the Critical Path Method as the most effective means for planning, scheduling and controlling construction projects, and I now present F. J. Raskopf, Jr., associate systems engineer, IBM Corporation, who will explain the CPM and demonstrate its use in railroad projects. Mr. Raskopf.

Critical Path Method for Railway Engineering

By F. J. RASKOPF, JR.

Associate Systems Engineer, International Business Machines Corporation

PART I

I have just completed discussions with engineers at a dozen companies on the results they have had in using the technique called the "Critical Path Method." These fellows were with firms in the manufacturing business, the construction business, and for the most part, the railroad business.

I must say that in most cases the results of using CPM were outstanding. The more you see what various outfits are doing with CPM, and see the real improvement and profit that are resulting, the more impressed you become with the potential of the Critical Path Method, and the wider become the possible uses of CPM in the railway engineering business.

Let's look at some of the results which a few firms are having. I will get on to some of the technicalities of CPM a little later on. But now, let's see some of the results. First, let's take the case of the Bessemer & Lake Erie Railroad Company out in Greenville, Pa.

Fig. 1 shows this road's coal handling facility in Erie, Pa., which was put up almost entirely with company forces in 1963. This project includes coal transfer facilities, such as conveyors, a car puller, bin, thawing equipment and tracks, and cost $170,000. This complex required the efforts of several Bessemer departments—track, bridge and building, and mechanical and electrical engineering—as well as outside contractors. Construction time was three months.

This was the first project on which Bessemer tried the Critical Path Method, and it had great success. First, it got stronger cooperation between the various engineering departments—they each saw exactly at which date they were going to be expected to contribute given portions of their work, and they saw exactly what problems would be caused for other departments if they were late.

Secondly, they beat both their time estimates and the cost estimates on this job. In fact, they say that since Bessemer adopted CPM, they have *never* gone over their cost estimate.

Third, and maybe the most noticeable change, was an improvement in morale. Whereas on earlier projects, there was confusion and overtime, and recriminations after each delay, CPM brought about a complete absence of confusion. All concerned knew exactly what they had to do and they did it.

Fig. 1.

With this record established on the Erie project, Bessemer tried CPM on its next job, a new undergrade bridge at Cranesville, Ohio. On this project a nine-track railroad bridge at the south end of the Cranesville Yard was to be replaced by one single-track and one double-track bridge, with corresponding changes in the arrangement of yard tracks.

CPM again provided dramatic results. Cost and time required were under estimates. Fewer men were needed on the job. There was complete coordination between the various departments and a complete absence of confusion.

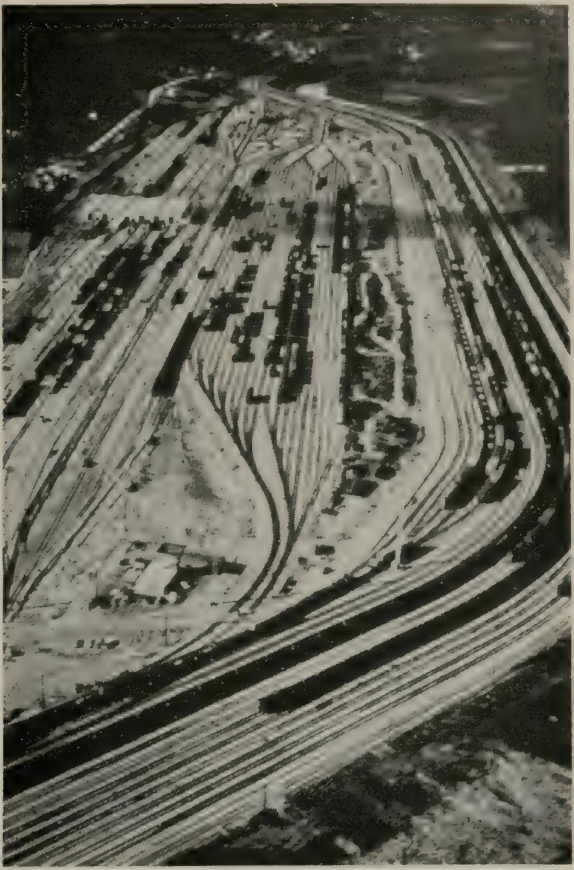
Bessemer was convinced of the value of CPM. The technique was subsequently used in the construction of two new 100-car capacity tracks. The road moved on to using CPM on a new yard and main-track rearrangement. Currently, it is giving CPM its biggest workout to date, on a multi-million dollar coal-handling facility at Conneaut, Ohio. This should be completed on time next month.

Now let's turn to an example on the Louisville & Nashville Railroad. The L&N began a major yard improvement project (Fig. 2) at DeCoursey, Ky., in July 1960—a $11½ million job, estimated to run for 4½ years.

After being progressed for two years, the work had fallen behind schedule. So the engineer of construction looked into CPM at that point to try to improve operations.

Like the B&LE, the L&N reports major benefits in its use of CPM. The DeCoursey project, which as I said had fallen behind schedule, got back on schedule and was completed ahead of the original estimate, in December of 1963. The road found that CPM induced into the supervisory and working forces alike a spirit of cooperation, and a drive to keep up with or better the schedule. It found that it was able to achieve a static work force, eliminate lay-off time, and thereby get more production per dollar spent.

Fig. 2.



For my third example I have chosen a building (Fig. 3) put up by my own company in Philadelphia and completed the first of this month. This is a 15-story office building. I chose this because it shows the advantages of CPM when all the architectural and construction work is done by contractors.

All contractors who bid on this job were required to submit what is called a CPM schedule along with their bids. Thus, CPM was used in the selection of a contractor. Then, when the contractor was selected, he was required to refine this CPM schedule, and when both he and IBM were in agreement, the schedule became part of the contract. This procedure is followed now on all IBM construction work, and has been for three years.

The advantage to the owner here is basically that he gets his building quicker. The contractor has made a more careful schedule, and he keeps on this schedule. Under the terms of the contract, he uses rescheduling and overtime when he falls behind, at no additional cost to the owner.

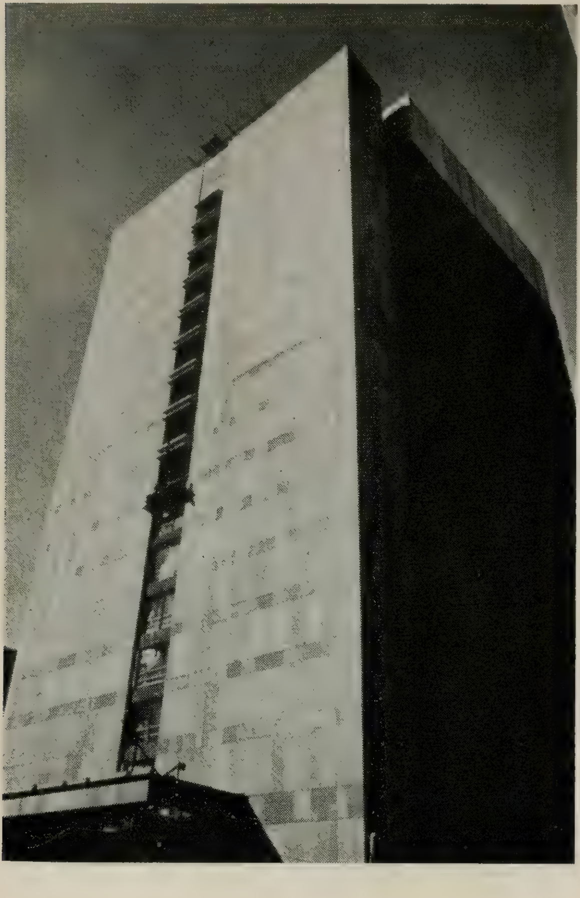


Fig. 3.

PART II

I wish I had time to show you more examples, because a lot of CPM experience is building up in other railroad companies, in construction firms, and in companies that are prime government contractors.

But let's get on to a look at the technique of the Critical Path Method itself.

I'm going to approach this from the standpoint of the three basic questions that CPM is designed to help you answer:

1. What must be accomplished?
2. How long will it take?
3. Can we improve the plan?

I've asked Bill Humphreys to work through the CPM technique for us. Bill, as all of you know, is the architect for the New York Central. He has been responsible for the design of numerous railroad buildings over some 20 years. Bill and I worked together on a critical path session which we held as a special feature of the Committee 6 meeting last year in New York. Since that time, Bill has completed a course in CPM and is now coordinating a CPM program on the Central.

We've selected as an example a passenger station (Fig. 4) designed by Bill's staff and built by the Central in Middletown, Ohio, at a cost of $40,000. The building makes use of pre-fab steel sections. Now let's see how Bill would have applied the Critical Path Method to planning the construction of this terminal.

Let's turn to the first question . . . what must be accomplished? The first step in answering this is to gain complete familiarity with the planned structure. He does this by going over the prints and specs (Fig. 5). Besides gaining familiarity with the design, he seeks to uncover any special problems which will come up due to the time of year, the labor situation in the construction area, and the construction details of the new building.

He visualizes all the construction activities that will have to go into this project—for example, site preparation, foundation work, structural steel and metal roofing, metal walls, doors and windows, plumbing, electric, and so on. At this point he's ready to start what is called the arrow diagram. This will be a picture of the complete construction project.

To answer the question "What must be accomplished?", he will now lay out on paper each major activity. He represents the first activity, "site prep," by drawing an arrow (Fig. 6), and writing the description above it.

Then he proceeds to indicate the following jobs as additional arrows: "excavation," "foundation," and "backfill." He uses circles as connectors.

He realizes that after site preparation, excavation work can also begin for outside utilities, so he shows this as a second arrow following "Site Prep." And he shows that after excavation is completed for outside utility lines, the outside lines can be laid (Fig. 7). He's going to continue in this fashion to lay out all the steps in the construction.

Fig. 8 is a complete network diagram of the Middletown station. It has a single starting point and a single finishing point. All the necessary construction activities are indicated, and we see their exact inter-relationship . . . we see exactly which activities have to be finished before others can start. We can see exactly which activities will be held up if a delay occurs in any other activity.

I would like to relate CPM to Gantt Charting throughout this talk. The main points of difference between the CPM network and a Gantt Chart at this point are, first, that the length of the arrows on the CPM network has no relation to the expected time the activity will take. On a Gantt Chart, of course, the length of the bar does show how long the activity is expected to take.

Secondly, the CPM network shows very specifically what the relationship is between separate activities and exactly which activities are held up by the completion of specific preceding ones. The Gantt Chart, on the other hand, does not show the complete picture of these relationships.

Now that the complete project network has been worked out, we can ask Bill our second question, "How long will it take?" Bill now goes over his diagram, looks at the activities one by one, and estimates how long each should take, based on his experience, and also based on a normal work week, without overtime. He proceeds through the network, considering each activity by itself, and estimating expected times.

A very important point is that he keeps his mind away from any pre-established deadline. His objective is not to make the total of all the estimates come out to a pre-established deadline date. It is just the opposite: he wants to establish how long each activity can really be expected to take, and then he will add them up to determine the time required to finish the whole project.

(Text continued on page 729)

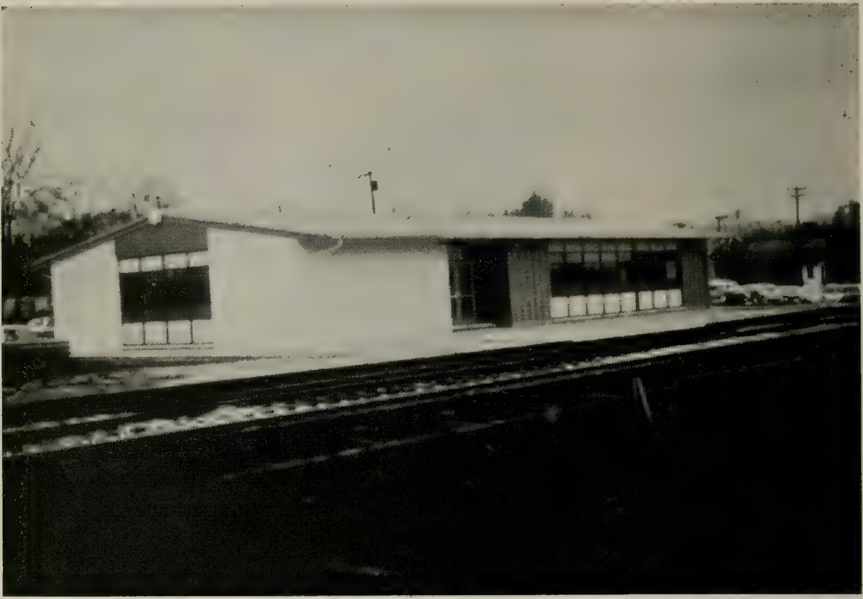


Fig. 4.

Fig. 5.

Fig. 6.

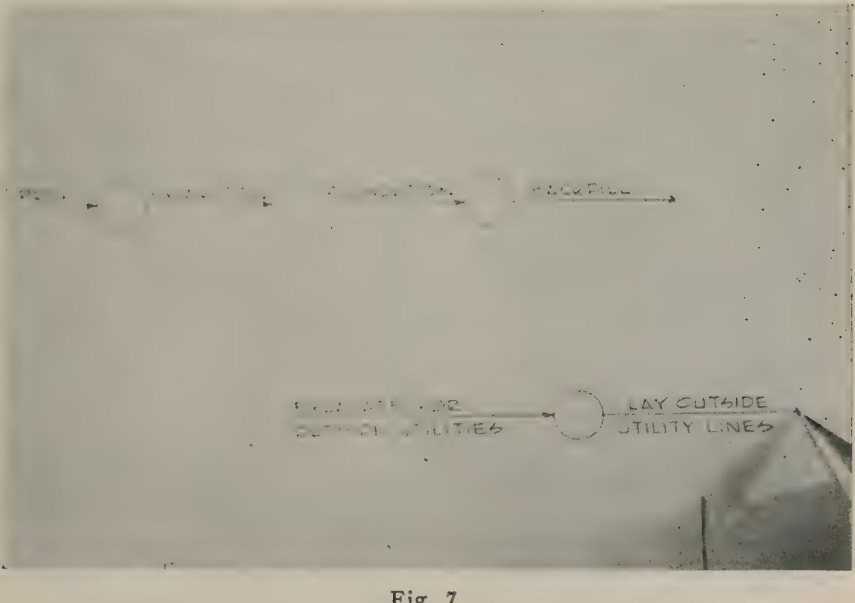


Fig. 7.

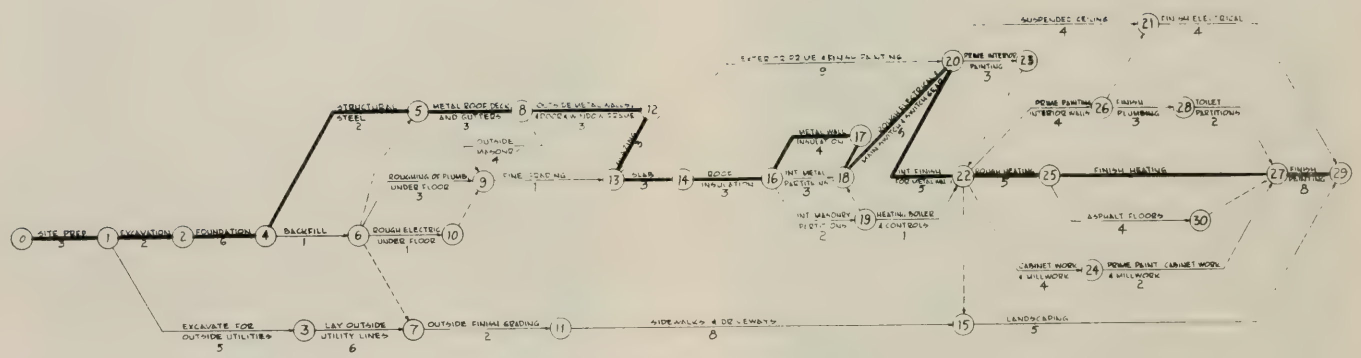

SITE PREP 3
EXCAVATION 2
FOUNDATION 6
BACKFILL 1
STRUCTURAL STEEL 2
METAL ROOF DECK AND GUTTERS 3
OUTSIDE METAL WALLS, DOORS & WINDOW FIXTURE 3
OUTSIDE MASONRY 4
ROUGHING OF PLUMB. UNDER FLOOR 3
ROUGH ELECTRIC UNDER FLOOR 1
FINE GRADING 1
GLAZING 3
SLAB 3
ROOF INSULATION 3
METAL WALL INSULATION 4
INT METAL PARTITIONS 3
INT MASONRY PARTITIONS 2
HEATING BOILER & CONTROLS 1
ROUGH ELECTRICAL 5
MAIN SWITCH & SWITCH GEAR 5
INT FINISH FOR METAL WALL 5
EXTERIOR PRIME & FINISH PAINTING 9
PRIME INTERIOR PAINTING 3
SUSPENDED CEILING 4
FINISH ELECTRICAL 4
PRIME PAINTING INTERIOR WALLS 4
FINISH PLUMBING 3
TOILET PARTITIONS 2
ROUGH HEATING 5
FINISH HEATING
ASPHALT FLOORS 4
CABINET WORK & MILLWORK 4
PRIME PAINT CABINET WORK & MILLWORK 2
FINISH PAINTING 8
EXCAVATE FOR OUTSIDE UTILITIES 5
LAY OUTSIDE UTILITY LINES 6
OUTSIDE FINISH GRADING 2
SIDEWALKS & DRIVEWAYS 8
LANDSCAPING 5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30

Fig. 8.

At this point, I would like to mention the word "Pert." This is a special form of the Critical Path Method developed by the Navy. It is basically the same as CPM, but it requires that you consider the maximum and minimum time possibilities in making your estimates.

Now to finish answering the question, "How long will it take"?, Bill starts adding up individual times in order to arrive at the total expected time.

For example, the time to complete the first two activities (Site Prep and Excavation) is the total of 3 days and 2 days, 5 working days.

Let's go further into the network. How long will it take to get to point 9, where fine grading can begin?

We find that there are several different sequences leading up to point 9, and all of this work has to be finished before we can start the job which comes out from point 9 (Fig. 9).

It turns out that that sequence of jobs which takes the longest amount of time determines when we can start "fine grading". The other sequences leading up to point 9 have a certain amount of slack or float in them.

Now, let's look at the whole network. Fig. 10 shows the longest sequence of jobs, which you determine by looking over the network, and comparing all alternate routes. The longest path, or critical path, is 60 working days long, and this determines when our project will be completed.

This answers the question we asked Bill, "How long will it take?" He can refer to a calendar now and express the expected completion as a calendar date. If work began on Tuesday, March 9, 60 working days would bring the completion date to June 1st.

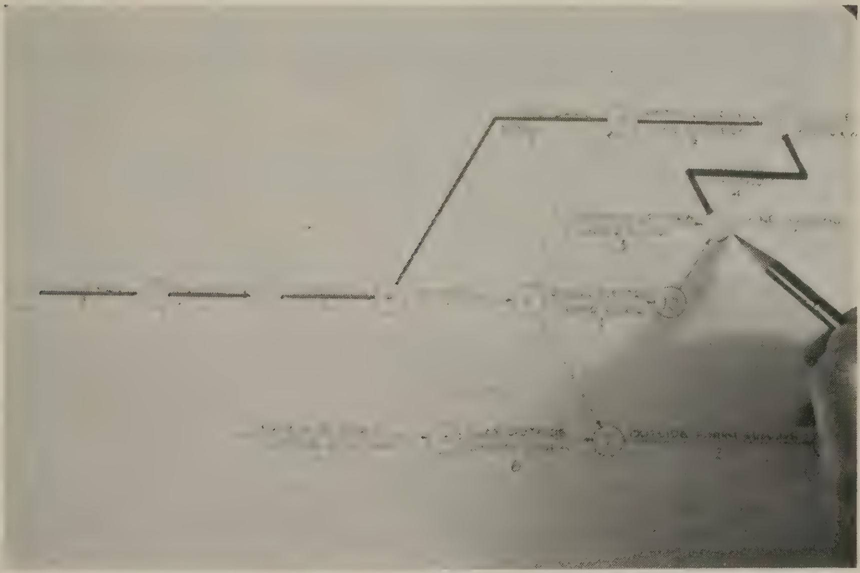


Fig. 9.

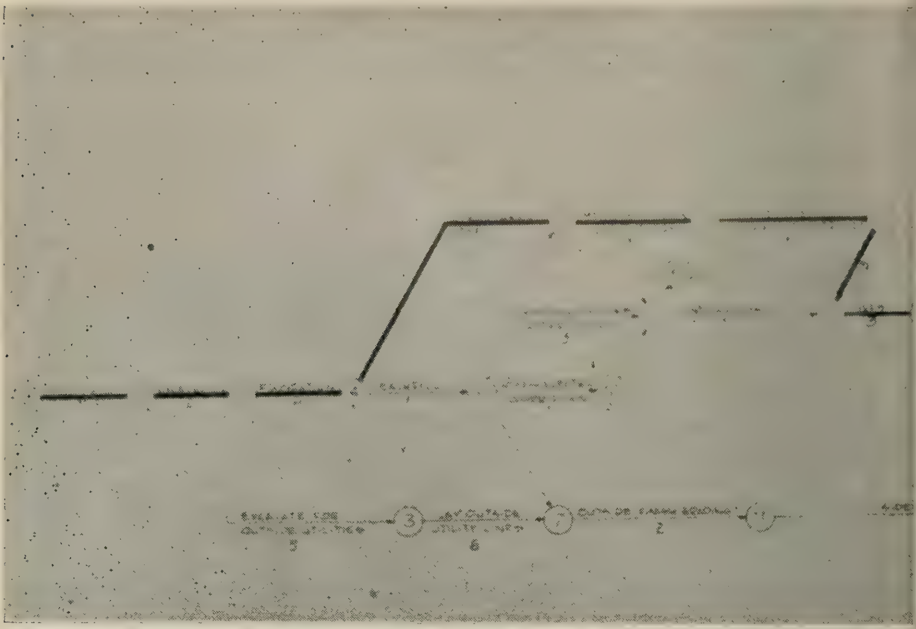


Fig. 10 (left portion).

Before we leave this question of "How long will the project take?", I should like to mention the way a computer could be used here. You can use the computer to do all the comparisons and calculations for you. In other words, the computer will calculate the total number of working days required for the project, will find the critical path, determine how much slack exists in all the other activities, and specify the calendar dates on which each activity should start and finish.

To use the computer, all you do is punch up a card for each activity, including the time estimate, feed the cards to the computer and let it do the calculating for you. In less than five minutes, the computer will print a complete report (Fig. 11), showing you the total number of days required for the project, as well as the date when the project should be finished. The same report will also tell you when each activity can be scheduled to start, whether it is on the critical path, and how much slack exists in each job.

At this point, I should like to make another comparison with the Gantt Chart. The Gantt Chart gives a clear picture of the expected starting date and ending date for each activity, as well as the target completion date.

CPM does this too, and in addition, it shows precisely how much slack exists in each activity. So considering slack, a CPM schedule shows us the earliest *and* latest possible start date, and earliest *and* latest possible finish date. We see the specific range within which we have to schedule the start of each activity—and exactly how much flexibility we have before we jeopardize our completion date.

Bill has found by using CPM that construction should be completed by June 1st if the present schedule is carried out. How does that fit in with management's plans?

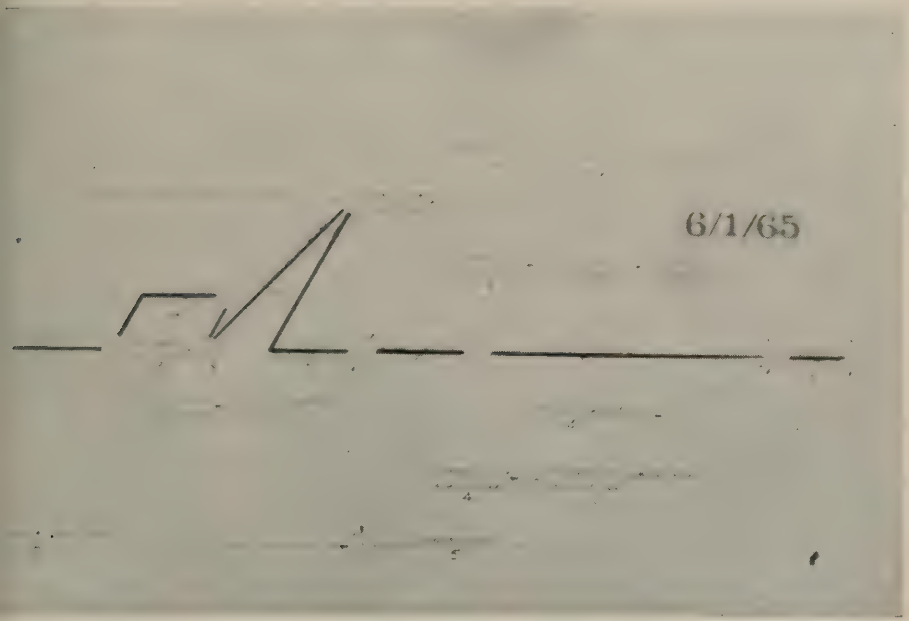


Fig. 10 (right portion).

Fig. 11.

COMPUTER-PRODUCED C.P.M. REPORT

Showing the results of "C.P.M. computations" for the New York Central Middletown Passenger Station. The report should be interpreted as follows:

DESCRIPTION - refers to individual activities.
* - indicates activity on the "Critical Path".
I-NODE - refers to number at tail end of arrow.
J-NODE - refers to number at head end of arrow.
DURATION - number of days required per activity.
TURNS - a term for the number of shifts (unused).
ESD - "Early Start Date", the first possible day on which this activity could start.
EFD - "Early Finish Date", completion date for the activity, assuming work started on the "ESD"
LSD - "Late Start Date", the latest possible date the activity could start and still allow on-time project completion.
LFD - "Late Finish Date", the completion date of the activity, assuming it was begun on the "LSD".
TF - "Total Float", maximum allowable delay on this activity, without delaying project completion.
FF - "Free Float", maximum allowable delay on this activity, without delaying start of next activity.

The EFD (or LFD) of the final activity, "FINISH PAINTING", indicates the overall project completion date, 06/01/65.

NOTE: Report produced on the IBM 1401 computer, using program number 1401-10.3.025, "LESS IV".

(Fig. 11 continued on next page)

Fig. 11 (continued)

MIDDLETOWN PASSENGER STATION --- NEW YORK CENTRAL --- CONSTRUCTION SCHEDULE

DESCRIPTION		I-NODE	J-NODE	DURATION	TURNS	ESD	EFD	LSD	LFD	TF	FF
SITE PREPARATION	*		1	3.		03/09/65	03/12/65	03/09/65	03/12/65	.	.
EXCAVATION	*	1	2	2.		03/12/65	03/16/65	03/12/65	03/16/65	.	.
EXCAVATE FOR OUTSIDE UTI		1	3	5.		03/12/65	03/19/65	04/26/65	05/03/65	31.	.
FOUNDATION	*	2	4	6.		03/16/65	03/24/65	03/16/65	03/24/65	.	.
LAY OUTSIDE UTILITY LINE		3	7	6.		03/19/65	03/29/65	05/03/65	05/11/65	31.	.
BACKFILL		4	6	1.		03/24/65	03/25/65	03/25/65	03/26/65	1.	.
STRUCTURAL STEEL	*	4	5	2.		03/24/65	03/26/65	03/24/65	03/26/65	.	.
ROUGH ELECT UNDER FLOOR		6	10	1.		03/25/65	03/26/65	04/06/65	04/07/65	8.	.
ROUGH PLUMBING UNDER FLO		6	9	3.		03/25/65	03/30/65	04/02/65	04/07/65	6.	5.
DUMMY		6	5	.		03/25/65	03/25/65	03/26/65	03/26/65	1.	1.
DUMMY		6	7	.		03/25/65	03/25/65	05/11/65	05/11/65	33.	2.
METAL ROOF DECK + GUTTER	*	5	8	3.		03/26/65	03/31/65	03/26/65	03/31/65	.	.
DUMMY		10	9	.		03/26/65	03/26/65	04/07/65	04/07/65	8.	7.
OUTSIDE FINISH GRADING		7	11	2.		03/29/65	03/31/65	05/11/65	05/13/65	31.	.
EXT WALLS, DOOR + WINDOW	*	8	12	3.		03/31/65	04/05/65	03/31/65	04/05/65	.	.
OUTSIDE MASONRY		8	9	4.		03/31/65	04/06/65	04/01/65	04/07/65	1.	.
SIDEWALKS AND DRIVEWAYS		11	15	8.		03/31/65	04/12/65	05/13/65	05/25/65	31.	18.
GLAZING	*	12	13	3.		04/05/65	04/08/65	04/05/65	04/08/65	.	.
FINE GRADING		9	13	1.		04/06/65	04/07/65	04/07/65	04/08/65	1.	1.
SLAB	*	13	14	3.		04/08/65	04/13/65	04/08/65	04/13/65	.	.
EXT PRIME + FINISH PAINT		13	20	9.		04/08/65	04/21/65	04/16/65	04/29/65	6.	6.
ROOF INSULATION	*	14	16	3.		04/13/65	04/16/65	04/13/65	04/16/65	.	.
INT MASONRY PARTITIONS		16	19	2.		04/16/65	04/20/65	04/20/65	04/22/65	2.	.
INTERIOR METAL PARTITION		16	18	3.		04/16/65	04/21/65	04/19/65	04/22/65	1.	1.
METAL WALL INSULATION	*	16	17	4.		04/16/65	04/22/65	04/16/65	04/22/65	.	.
BOILER AND CONTROLS		19	22	1.		04/20/65	04/21/65	05/05/65	05/06/65	11.	11.
DUMMY		19	18	.		04/20/65	04/20/65	04/22/65	04/22/65	2.	2.
ROUGH ELECT + MAIN SWITC	*	18	20	5.		04/22/65	04/29/65	04/22/65	04/29/65	.	.
DUMMY	*	17	18	.		04/22/65	04/22/65	04/22/65	04/22/65	.	.
PRIME INTERIOR PAINTING		20	23	3.		04/29/65	05/04/65	05/03/65	05/06/65	2.	.
SUSPENDED CEILING		20	21	4.		04/29/65	05/05/65	05/10/65	05/14/65	7.	5.
INTERIOR FIN METAL WALLS	*	20	22	5.		04/29/65	05/06/65	04/29/65	05/06/65	.	.
DUMMY		23	22	.		05/04/65	05/04/65	05/06/65	05/06/65	2.	2.
HANG DOORS		22	27	2.		05/06/65	05/10/65	05/18/65	05/20/65	8.	8.
PRIME PAINT INTERIOR WAL		22	26	4.		05/06/65	05/12/65	05/07/65	05/13/65	1.	.
CABINET WORK AND MILLWOR		22	24	4.		05/06/65	05/12/65	05/13/65	05/19/65	5.	.
ROUGH HEATING	*	22	25	5.		05/06/65	05/13/65	05/06/65	05/13/65	.	.
LANDSSAPING		15	29	5.		05/06/65	05/13/65	05/25/65	06/01/65	13.	13.
DUMMY		22	15	.		05/06/65	05/06/65	05/25/65	05/25/65	13.	.
PRIME PAINT CABINET + MI		24	27	1.		05/12/65	05/13/65	05/19/65	05/20/65	5.	5.
FINISH PLUMBING		26	28	3.		05/12/65	05/17/65	05/13/65	05/18/65	1.	.
FINISH ELECTRICAL		21	27	4.		05/12/65	05/18/65	05/14/65	05/20/65	2.	2.
DUMMY		26	21	.		05/12/65	05/12/65	05/14/65	05/14/65	2.	.
ASPHALT FLOORS		25	30	4.		05/13/65	05/19/65	05/14/65	05/20/65	1.	.
FINISH HEATING	*	25	27	5.		05/13/65	05/20/65	05/13/65	05/20/65	.	.
TOILET PARTITIONS		28	27	2.		05/17/65	05/19/65	05/18/65	05/20/65	1.	1.
DUMMY		30	27	.		05/19/65	05/19/65	05/20/65	05/20/65	1.	1.
FINISH PAINTING	*	27	29	8.		05/20/65	06/01/65	05/20/65	06/01/65	.	.

Is this date acceptable? Let's say that management has set a target date of May 27. This means that June 1st is 3 days over target.

This is where we can use the CPM to answer the third basic question, "Can we improve the plan?"

Again, let's see how Bill would go about answering this question. He goes back to his network diagram.

Remember, the overall time to complete this construction is determined by the time for the jobs that make up the longest route through the network. A certain amount of slack exists in all the others.

Now, here is one of the most important points in the CPM. Since the longest route (or the Critical Path) is what determines completion date, to reduce the total construction time, the individual jobs on the longest path have to be cut down.

Let's look at that more closely (Fig. 12). If we want to reduce overall construction time, does it do any good to add extra men on jobs like rough plumbing, exterior painting, or finish electrical, which are not on the critical path? No, it doesn't help a bit. All we do is provide more slack in these jobs. The overall project still won't be done before June 1. In other words, we would be throwing away money if we put on extra crews for non-critical jobs because we wouldn't move up our completion date at all. But let's see what happens when we put extra men on critical jobs.

Either by adding additional men to work on the critical jobs, or by shifting men over from jobs which have slack, we can cut down on the length of the longest sequence. In Fig. 13 we show that one day has been cut out of each of three so-called critical jobs. This resulted in moving up our completion date from June 1 to May 27.

Besides adding to crew size to expedite critical jobs, a second method is possible for improving upon our plans. This includes actually changing the sequence of work.

I would like to illustrate this. On Fig. 14 (a) we see a portion of the original network. If you can read it, you will see that *after* roof insulation is finished, *then* work starts on Metal Wall Insulation, Interior Metal Partitions, and Interior Masonry Partitions. This sequence takes 7 days.

On Fig. 14 (b) we see how three days can be cut out of this sequence. Here, we start Metal Wall Insulation, Interior Metal Partitions, and Interior Masonry Partitions *at the same time* as we start Roof Insulation, instead of after this job is finished.

Now the plan has been improved by one technique or another to the point where it meets the deadline. New calculations are made to determine the start dates for each job under the revised schedule. When this point has been reached we can bring the CPM network (Fig. 15) more closely into the format of the Gantt Chart. Vitro Engineering in New York, for one, uses this technique. They redraw the final network against a time scale, so that it now becomes more familiar in appearance to those engineering and construction people who are used to seeing Gantt charts.

(Text continued on page 737)

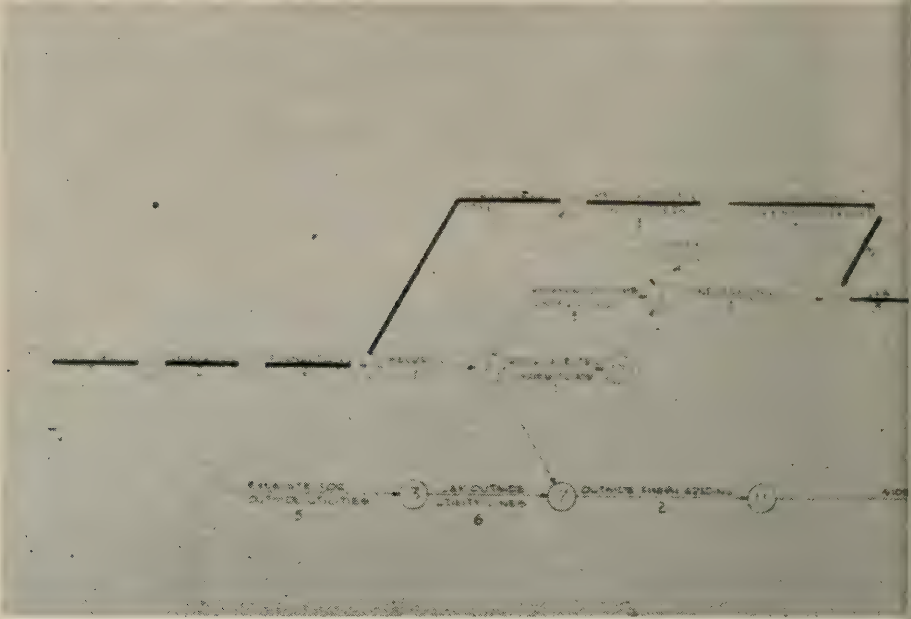


Fig. 12 (left portion).

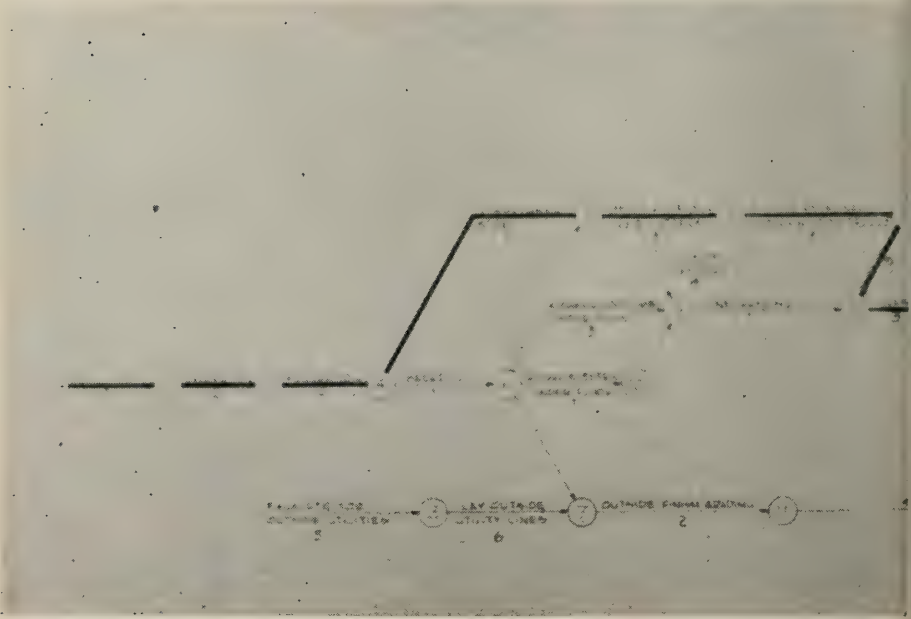


Fig. 13 (left portion).

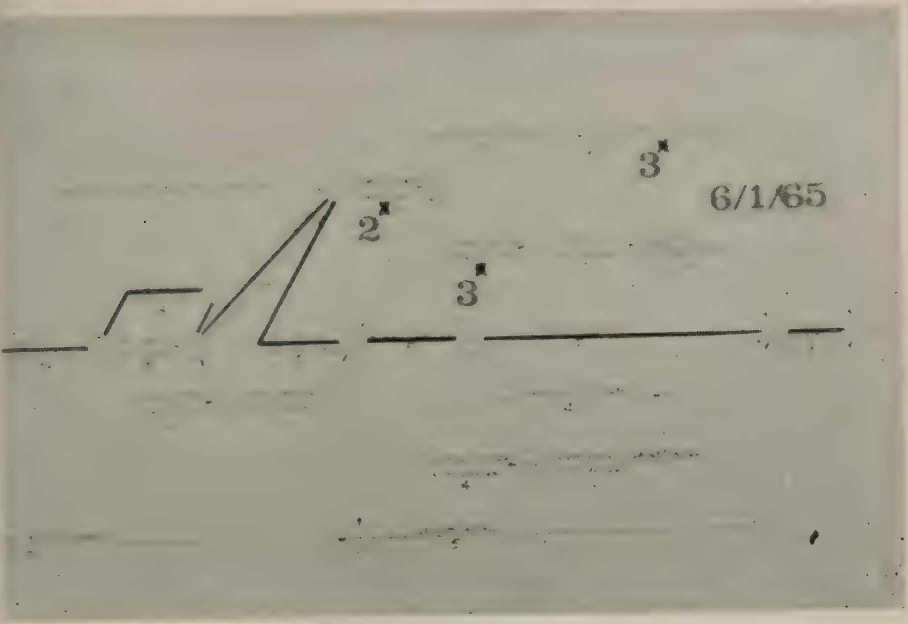


Fig. 12 (right portion).

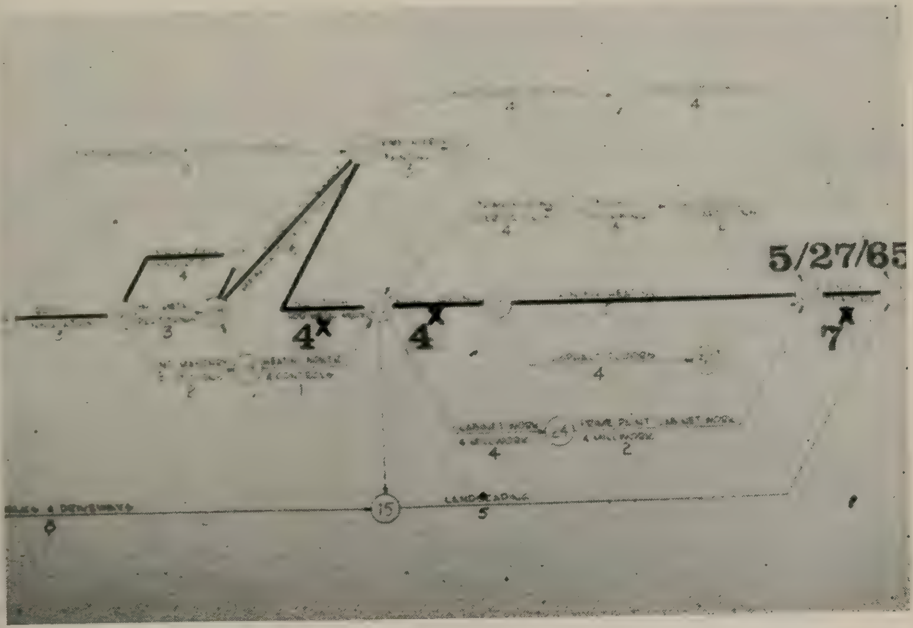


Fig. 13 (right portion).

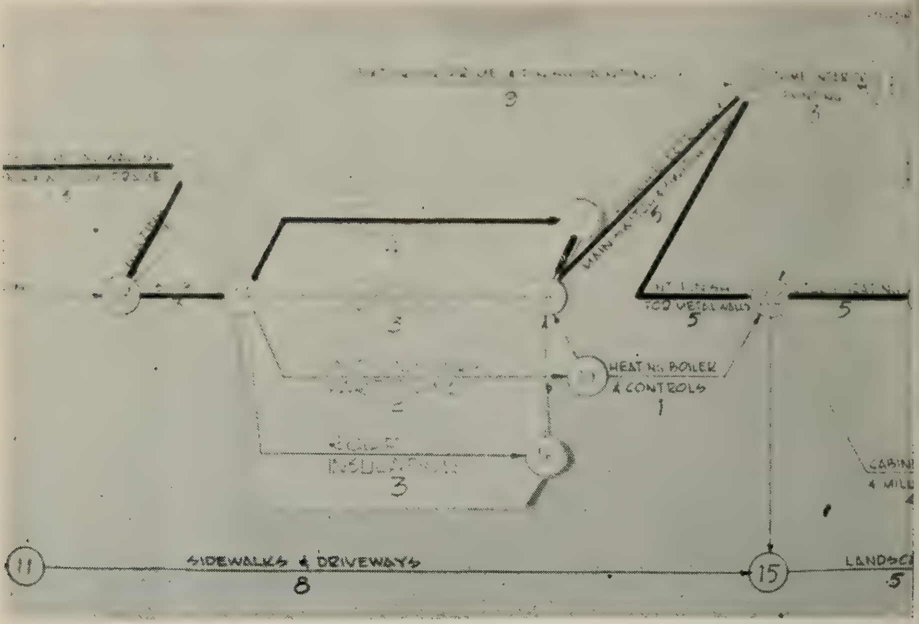


Fig. 14 (a).

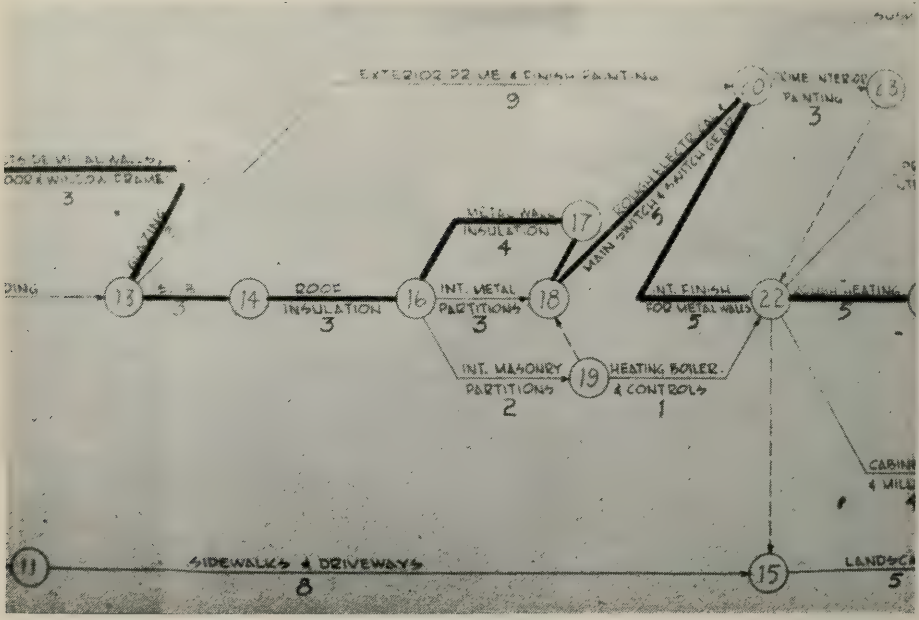


Fig. 14 (b).

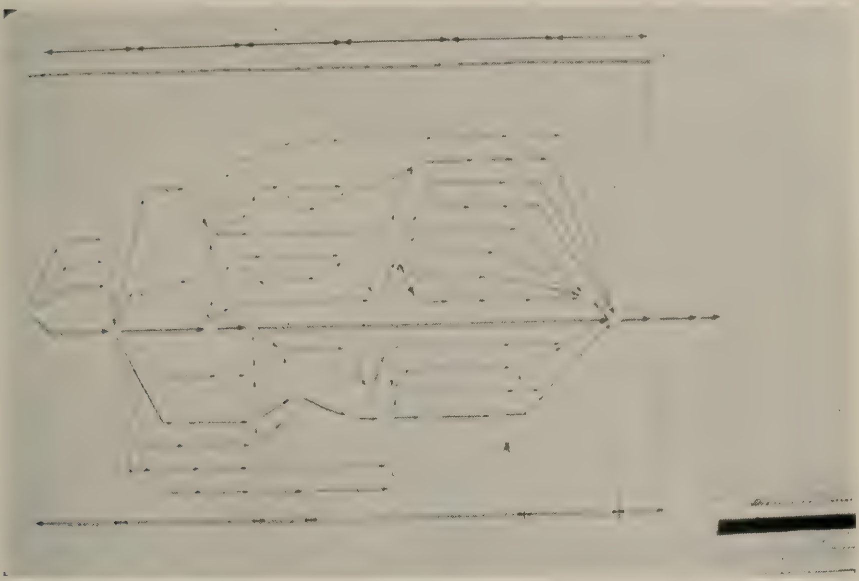


Fig. 15.

PART III

Bill is pretty pleased with the job he has done so far. He has explained the basic principles of CPM to us in theory. But we can't have him stop there. What we need to look at now is how a railway engineering department can put these principles into practice.

How do they prove to themselves that the principles of CPM will really work for them? The answer is, they should conduct a trial (Fig. 16) of the Critical Path Method by using it on an actual construction project. I should like to go over the steps that should be taken to properly give CPM a fair test.

To start with, a meeting is held between engineering executives to initiate the CP project test. At this time, a test project is selected. To get a real feel for the benefits of CPM, this project must be an actual construction that is still in the planning phase.

Also during his session, a CPM coordinator is selected. As we shall see, he will become the manager of the Critical Path effort.

The next step is to have the Critical Path coordinator train himself to the level of "expert" in the Critical Path Method. He will want to fully understand all the techniques of diagramming and computation. To begin with, he will read articles on the basics of CPM.

He may also wish to have discussions with engineers of other firms who have already had experience with the Critical Path Method. He will want to find out how they went about it, how it worked out, and what their suggestions are, concerning possible pitfalls.

When the coordinator has completed his formal training, he will begin to answer our first question "What must be accomplished?" He will sketch out a tentative network for the selected project.

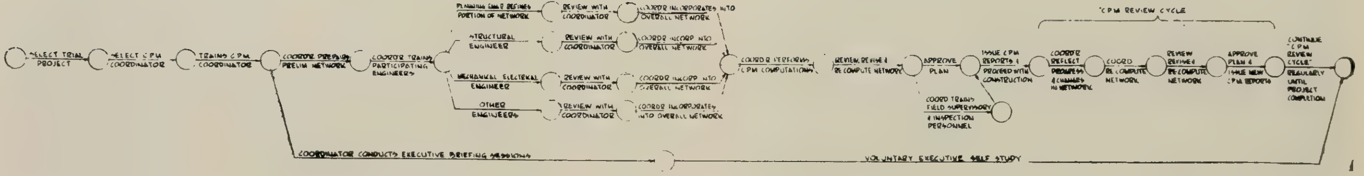

SELECT TRIAL PROJECT
SELECT CPM COORDINATOR
TRAINS CPM COORDINATOR
COORD'R PREPARES PRELIM NETWORK
COORD'R TRAINS PARTICIPATING ENGINEERS
PLANNING ENG'R REFINES PORTION OF NETWORK
STRUCTURAL ENGINEER
MECHANICAL ELECTRICAL ENGINEER
OTHER ENGINEERS
REVIEW WITH COORDINATOR
REVIEW WITH COORDINATOR
REVIEW WITH COORDINATOR
REVIEW WITH COORDINATOR
COORD'R INCORPORATES INTO OVERALL NETWORK
COORD'R INCORP INTO OVERALL NETWORK
COORD'R INCORP INTO OVERALL NETWORK
COORD'R INCORPORATES INTO OVERALL NETWORK
COORD'R PERFORMS CPM COMPUTATIONS
REVIEW, REVISE & RE COMPUTE NETWORK
APPROVE PLAN
ISSUE CPM REPORTS & PROCEED WITH CONSTRUCTION
COORD TRAINS FIELD SUPERVISORY & INSPECTION PERSONNEL
"CPM REVIEW CYCLE
COORD'R REFLECT PROGRESS & CHANGES IN NETWORK
COORD RE COMPUTE NETWORK
REVIEW REVISE & RE COMPUTE NETWORK
APPROVE PLAN & ISSUE NEW CPM REPORTS
CONTINUE "CPM REVIEW CYCLE" REGULARLY UNTIL PROJECT COMPLETION
COORDINATOR CONDUCTS EXECUTIVE BRIEFING SESSIONS
VOLUNTARY EXECUTIVE SELF STUDY

Fig. 16.

But he won't go into complete detail because he is not in a position to know how all details will be handled. Instead, he will want the engineering managers responsible for specific portions of the job to be the ones who develop the detailed network. A basic principle of CPM is that the men responsible for planning should make the network.

Next, and very important, the coordinator will conduct a CPM briefing session for certain executives in the firm. It is very necessary to have executive understanding and support for the CP effort.

Next, he will provide training sessions for all the managers of engineering departments which are going to become involved.

As an example of the length of these sessions, Raytheon trained 100 of their engineering people in CPM, and found that a series of 5 sessions, each 2½ hours long, worked out very well.

After they have completed their training, the engineering managers now work out the details of that portion of the network for which they are responsible. The coordinator works with them, and in turn he incorporates their work into one large overall network which he maintains in his own office.

Again, to give some indication of the time involved, Raytheon has found that a network of 160 arrows takes from 5 to 8 hours of effort to develop.

The coordinator then performs the computations on the network. Let me say that this can certainly be done without a computer, and in fact it should be done by hand for small networks. But when the network grows to over 100 activities, the coordinator will find it is much faster and easier to use the computer.

The coordinator then holds a review session with the engineering managers to approve the CPM schedule. If the allowable project time has been exceeded, revisions are made in scheduling and staffing to reduce the total time required for the job.

A training session should now be held for the field supervisory personnel. This will be the third and final group which the coordinator must train. This group must have sufficient understanding of CPM to give it their full support. And they will have to become familiar with how to use the CPM schedules they are going to be receiving.

These schedules can then be issued to the field, and work on the project can start.

At the end of one month, the field will report all the jobs which were started and completed, and how many days of work remain on those jobs which are in progress. The field will also report any foreseeable changes which should come up, such as strikes or construction problems.

Now the coordinator begins a review and revising effort, called the "monthly CPM review cycle." Here, the effect of actual progress and future changes is evaluated by the engineering managers. If they determine that they have fallen behind schedule, they make revisions and modifications to plans. A new CPM schedule is prepared, and released to the field to replace the schedule they had last month.

Work now proceeds on the project for another month. At the end of that time, progress and any foreseeable changes are again reported, and the effect of these developments is computed. A review session is held to analyze these developments, and new control reports are issued.

This regular review is continued for the remainder of the construction effort. This is the way the supervisory and management people can completely understand actual progress being made, and make the changes which become necessary to keep the project moving ahead on schedule.

Before I leave this topic of conducting a CPM trial project, I should like to answer the question, "What should we do next?" In other words, we have selected our CPM coordinator, we have trained our people, we have successfully completed our trial construction project, and we have seen what CPM could do for us.

Well, the next step should be to use CPM on another project. This time our educational problem will be much easier because most of the personnel have already had direct experience. We shall modify and adapt it so it becomes easier for us to use and to understand.

Another thing we should do is to begin to get more assistance from the computer. Specifically, we can feed cards to the computer each month which reflect our progress to date. The computer then will compare progress against the original schedule and will tell us very quickly how we are doing. We can get concise reports showing exactly where we have fallen behind, and where our costs have gone out of line—in short, exactly how we stand and where we should take corrective action.

As far as IBM computers are concerned, the full range of CPM applications are available to run on all our computers. This includes the "old reliable" 1401 which many of you have in your companies. Also, the full range of CPM applications are available for the computer we have just come out with for the engineering profession. This computer is called the 1130.

PART IV

In closing, I'd like to go over the various areas of the railway engineering business where CPM could be used, and to summarize the advantages you could expect in each case.

The first is in the construction of buildings, small and large. CPM here will bring a great reduction in confusion as a result of complete pre-planning of the job. There won't be any surprises because the entire project has been worked out, and every one has been pinned down.

We can expect cost savings to result, somewhere around 10 percent; some experience has actually placed the reduction closer to 18 percent. Now where does this saving come from? Well, for one thing, we can virtually eliminate overtime or at least minimize the use of overtime and still stay on schedule. If we do fall behind, we don't place everything on overtime to speed up the job, but selectively use overtime on just the few critical jobs.

Secondly, we can expect to cut costs by reducing the work force, partly because we can cut down on the labor for jobs which we find are not on the Critical Path, and also because we can cut way down on idle time, thereby utilizing our work force more fully.

In the area of expediting, we can again effect a cost saving, because we can determine the cost of different levels of expediting, and can choose the economic way to expedite. For example, we may find that we can expedite by 20 days at a cost of $10,000 but to expedite 30 days would cost $100,000, Here, we may decide that the extra 10 days are not worth $90,000 to us, so we will only expedite by 20 days.

Another cost saving will come up in redesign. When we find that a fairly large amount of slack exists on a particular aspect of the job, we can use this time to re-design that portion more economically and can shop around for the most economical material supplier.

Maybe the biggest cost saving is really an increase in profit. By using CPM, we can get our building completed earlier. Depending on the use to which that building

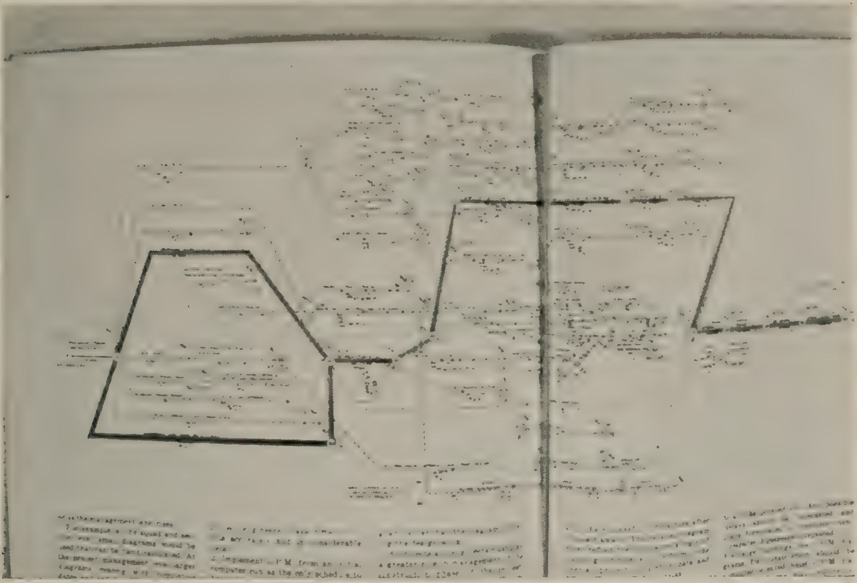


Fig. 17.

will be put, the early completion may mean substantial additional revenue for the company.

A second major area for CPM is in yard and track work. Here the same advantages would apply. Timing is especially important in track work, where the facilities must be put back in service as quickly as possible. In using CPM on a very tight schedule, your durations may all be expressed in terms of hours instead of days. Then progress might be checked every hour, and when a delay occurs in a critical job, immediate action can be taken to get back on schedule.

Bridge construction is another area of railway work where we can use CPM. Here, since the work would usually be done by contractors, I will review the advantages to the railroad even when its own crew is not used.

A CPM schedule can be required from all bidders, and selection can then be made on a more factual basis . . . in other words, you'll know exactly how he intends to go about the job and will see how he arrived at his time estimate. The CPM schedule can then become part of the contract, and the contractor can be required by contract to live up to it. The contractor can be required to submit a CPM progress report every month and when he falls behind, he will show how he intends to get back on schedule. This can include the use of overtime at no additional cost to the owner. The progress report can also serve as a basis for percent completion payments to the contractor. CPM works to the contractor's advantage here, too. When the owner tells him to hurry up, he can show why this may be impossible, or if you insist on a speed-up, the contractor can show you exactly what will be involved, and how much more it will cost. In short, in a contractor situation CPM gives the owner more control over construction than any other tool yet developed.

Maintenance is another application of CPM. The oil companies have made extensive use of CPM here. Your network would show the plan for removing a given facility from service and routing traffic elsewhere. Then the actual maintenance work can be planned for the quickest possible completion. If a sufficient amount of slack does show up in the maintenance job, this time can be utilized for additional replacement work, so that future operation and maintenance becomes easier and cheaper.

The final use of CPM that I'm going to talk about is right in the operation of the architectural or the engineering department itself. Each project taken on can be planned with CPM, in sufficient detail to insure that work will be released on time, with a given work force.

In the diagram shown in Fig. 17, which is from *Architectural Record*, at the left we have such activities as Preliminary Project Meeting, Site Study, Information and Drawings from Client, and so on. Then toward the center we have Start Structural Design, Finish Structural Design, Start Architectural Plans, Finish Architectural Plans, etc. Then at the right we have Review and Approval, Bidding Period, Bid Review, Construction Budget Approval and Contract Award.

Again, we can reduce overtime and confusion to a bare minimum. We know day-by-day how we stand in terms of actual work completed, and we can make the changes that are necessary to release our work on time.

I hope this discussion has served to reaffirm the interest that many of you have shown in using CPM for railway engineering. I hope this will make it easier for you to get started, and I wish you the greatest success in your efforts. [Applause]

D. A. Bessey: On behalf of Mr. Hayes and Mr. Humphreys, our chairman and vice chairman, and on behalf of Committee 6, I should like to express our appreciation to Mr. Raskopf for his presentation.

Mr. Humphreys had to leave early and asked me to express his apologies to the Association. He has to be in Massachusetts at eight o'clock tomorrow morning, and he had to catch a train.

Mr. President, this concludes the report of Committee 6.

Vice President Trissal: Thank you, sir. That certainly was an excellent report, and I trust you will convey to Messrs. Hayes and Humphreys the appreciation of the Association for their fine report.

To you, Mr. Raskopf, we likewise express our appreciation for your excellent dissertation on the Critical Path Method. I am sure we have all found it of great interest.

The committee is excused with the thanks of the Association. [Applause]

[President Burris resumed the Chair.]

Discussion on Maintenance of Way Work Equipment

[For report, see Bulletin 589, pages 273–289]

President Burris: The next report is that of Committee 27—Maintenance of Way Work Equipment. The chairman of this Committee is R. W. Baley, engineer of scales and work equipment, Chicago & North Western Railway, Chicago. Will Mr. Bailey and his committee members please come to the platform.

Gentlemen, you may be interested in the latest attendance report. As of 3:30 pm there were 1380 railroad men registered, 1033 non-railroad men, for a total of 2413. This is a new record.

Mr. Bailey, you may proceed.

Chairman R. W. Bailey: Your committee wishes to express its sorrow at the death on November 25, 1964, of F. E. Short, district engineer, St. Louis–San Francisco Railway, at Tulsa, Okla. Mr. Short was a long-time member of Committee 27, and a memoir in his honor has been prepared for publication in the proceedings. It was written by J. O. Elliott, general supervisor work equipment, St. Louis–San Francisco Railway, Springfield, Mo.

MEMOIR

Forrest Edwin Short, Sr.

Forrest Edwin Short, Sr., district engineer, St. Louis–San Francisco Railway, Tulsa, Okla., died on November 25, 1964, following an illness of several months duration. He is survived by his wife, Mrs. Laura Elizabeth Short, and two sons, Forrest E. Short, Jr., and Joe Bradley Short, both of Ft. Scott, Kans.

Mr. Short was born February 4, 1904, in Mountain Grove, Mo. He attended Drury College and University of Missouri at Rolla. He entered service with the St. Louis–San Francisco in 1924 and for 38 years worked in the engineering department in various engineering and maintenance capacities in Springfield, Mo., Birmingham, Ala., Kansas City, Mo., and Mobile, Ala. For many years he was division engineer on the Northern Division at Fort Scott, Kans.

Mr. Short was a member of the Methodist Church in Fort Scott, and the Rotary Club and the American Legion. He served in World War II as a lieutenant colonel in the U. S. Army Engineers. He joined the AREA in 1947 and was appointed to membership on Committee 27 in 1952, which membership he held until his death.

Mr. Short was a valued member of this committee and had contributed greatly to its work. He will always be remembered by the members for his work and assistance as well as his friendship and humor, and it is with a deep sense of appreciation of his association with us that Committee 27 records this tribute to his memory.

Chairman Bailey: The reports of Committee 27 will be found in Bulletin 589, Vol. 66, pages 273–289, incl.

We are reporting on eight assignments, and our presentation will be confined to a brief summary of the published reports only. To understand and benefit from the complete reports, your committee urges each of you to read and study the information contained in them.

Assignment 1—Revision of the Manual

Chairman Bailey: The chairman of Subcommittee 1 is R. M. Johnson, supervisor work equipment—system, Western Maryland Railway, Baltimore, Md., who will present his report.

R. M. Johnson: Your committee recommends the reapproval without change of Part 3 of Chapter 27 of the Manual, and I move that this recommendation be adopted.

[The motion was duly seconded, was put to a vote, and carried.]

Assignment 1 (a)—Revision of Handbook of Instructions for Care and Operation of Maintenance of Way Equipment

Chairman Bailey: The committee is studying a proposed revision of the Handbook. These revisions will require considerable work, and there is no report to submit at this time. The chairman is S. E. Tracy, superintendent of work equipment, Chicago, Burlington & Quincy Railroad, Chicago. Will Mr. Tracy please rise for recognition. Thank you, Mr. Tracy.

Assignment 2—Improvements to be Made to Existing Work Equipment

Chairman Bailey: This committee has been working with manufacturers on various improvements considered necessary on existing equipment. Emil Eskengren, process engineer, St. Louis–San Francisco Railway, Springfield, Mo., is chairman of this subcommittee. Will Mr. Eskengren please rise for recognition. Thank you, sir.

Assignment 3—Standardization of Parts and Accessories for Work Equipment

Chairman Bailey: A report was submitted on this assignment at the convention in March 1964. Your committee felt that this report covered sufficient ground for standardization of parts and accessories and that no further study was recommended. It is therefore recommended that this subject be discontinued.

Assignment 4—Switch Heaters and Other Devices or Machines for Removing Snow from Switches, Collaborating with Committee 18

Chairman Bailey: Information concerning this subject is being assembled from the various railroads represented on the committee, and a report will be submitted at the 1966 convention. The subcommittee chairman is J. W. Risk, superintendent work equipment, Canadian National Railways, Toronto, Ont. Will Mr. Risk please rise for recognition.

Assignment 5—Automation of Maintenance of Way Equipment

Chairman Bailey: The chairman of Subcommittee 5 is J. W. Winger, production engineer, Baltimore & Ohio Railroad, Baltimore, Md. Will Mr. Winger please summarize the report on this assignment.

J. W. Winger: Mr. President, members and guests of the Association. Your committee's report covers production tampers equipped with automatic jacking and leveling devices as an integral part of the basic tamper and is published in Bulletin 589. This report described four different types of tampers and their various components. It is a final report, submitted as information.

Assignment 6—Alternators and Transistorized Electrical Systems for Installation on Work Equipment

Chairman Bailey: The chairman of Subcommittee 6 is H. A. Thyng, supervisor of work equipment, Boston & Maine Railroad, Boston, Mass. In Mr. Thyng's absence H. E. Pottsmith, superintendent of work equipment, Chicago, Milwaukee, St. Paul & Pacific Railroad, Chicago, will summarize the report on this assignment.

H. E. Pottsmith: Mr. President, members and guests of the Association. The report on alternators and transistorized electrical systems for installation on work equipment may be found in Bulletin 589. This report covers the advantages and disadvantages in the use of alternators and various transistorized ignition systems on work equipment. The report is final and is submitted as information.

Assignment 7—Snow Removal Equipment

Chairman Bailey: The chairman of this subcommittee is H. F. Longhelt, assistant engineer maintenance of way, Illinois Central Railroad, Chicago. Will Mr. Longhelt please summarize his report.

H. F. Longhelt: Snow on railroad properties, throughout the history of the industry, has been a problem, but in recent years it has become even more troublesome, because of automation of our yards, switches, etc., and because of reduced labor forces.

A comprehensive report on snow removal equipment was presented by this committee some years ago and appears in the Proceedings, Vol. 48, 1947. Your committee believes there has been sufficient development of new equipment and improvement to existing equipment, during the years since the last report, to warrant this report as information.

The report does not cover standard-type plows and spreaders which have been in long use on line of road for snow removal, as there have been no substantial changes in this type of equipment. It does attempt to list both existing and new snow removal equipment and equipment not specifically designed for snow removal, which help combat snow in yards and terminal where it presents the greatest problems.

Assignment 8—Specifications for Equipment Purchase

Chairman Bailey: Your committee is writing specifications which it will recommend for use of equipment purchasers. These specifications are designed so that the purchaser will be assured of receiving a unit which will function reliably in sustained operation. The report is to be submitted in the future. The chairman of this subcommittee is F. H. Smith, assistant engineer, Atchison, Topeka & Santa Fe Railway, Chicago.

Chairman Bailey [continuing]: Mr. President, this completes the report of Committee 27.

President Burris: Thank you, Mr. Bailey. Are there any questions?

The development of our maintenance of way equipment over the years has illustrated the value of this committee to the Association, which is continuing.

Mr. Bailey, you and your committee are to be congratulated for your fine work. The committee is now excused with the thanks of the Association. [Applause]

President Burris [continuing]: Gentlemen, this concludes the proceedings of the afternoon session. You still have time to look at the show upstairs, which does not close until 5 pm. The convention is adjourned until nine o'clock in the morning. Please be prompt.

[The meeting adjourned at 3:55 pm]

Morning Session March 25, 1965

[The meeting reconvened at nine o'clock, President Burris presiding.]

President Burris: Gentlemen, please come to order. We are now commencing our final technical session of this Convention, which includes reports of four of our most popular committees and two outstanding special features.

Discussion on Roadway and Ballast

[For report, see Bulletin 591, pages 521–577]

President Burris: Appropriately, the first report will be given by Committee 1—Roadway and Ballast, the chairman of which is L. J. Deno, maintenance engineer, Chicago & North Western Railway, Chicago. Since Mr. Deno and the members of his committee are already in place on the platform, I shall turn the microphone over to him without further comment, except to remind those of you who desire to ask questions or comment on the report to stand and first give your name and railroad or other affiliation.

Mr. Deno, you may proceed.

Chairman L. J. Deno: Mr. President, members and guests:

During the past year Committee 1 held 2 regular meetings at which our 11 subcommittees reported progress on their assignments. Formal reports will be presented on 7 of the assignments. These reports are published in Bulletin 591, pages 521 to 577, incl. We invite your comments on these reports.

Assignment 1—Revision of Manual

Chairman Deno: Committee 1 has two recommendations for revision to the Manual which will be submitted by the subcommittee chairmen involved. F. N. Beighley, roadway engineer, St. Louis–San Francisco Railway, is chairman of Subcommittee 1. Mr. Beighley, will you stand and be recognized?

Assignment 2—Physical Properties of Earth Materials

Chairman Deno: Investigation has continued on this assignment but sufficient information has not been developed to report at this time.

W. P. Eshbaugh, chief engineer, Genessee & Wyoming Railroad, has been chairman of this subcommittee. Mr. Eshbaugh, will you stand and be recognized? Mr. Eshbaugh recently retired from railroad service, and I wish to take this opportunity to thank him for his many valuable contributions to the activities of Committee 1. M. B. Hansen, area engineer, Canadian National Railways, is the new chairman of this subcommittee.

Assignment 3—Natural Waterways

Chairman Deno: G. W. Becker, special engineer—drainage for the Chicago, Rock Island & Pacific Railroad, is chairman of this subcommittee and will present the report.

G. W. Becker: Mr. President, members and guests:

Your committee submits as information in Bulletin 591, a report on the use of soil-cement construction for bank protection on levees, embankments, and canal linings. This is a comparatively new type of protection being used on a few government installations at this time, primarily in areas where rip-rap is scarce.

The committee is also submitting for adoption and publication in the Manual, completely revised material on construction and protection of roadbed across reservoir areas. The new proposal also appears in Bulletin 591, February 1965, pages 523 to 532.

The present Manual material was first published in the Proceedings, Vol. 56, 1955, and approved for adoption in the Manual in 1956. Since that time, knowledge of wave characteristics and the protection of embankments from wind-generated waves has increased tremendously.

Your committee therefore submits the revised material for adoption, to replace existing material appearing in the Manual on pages 1–1–36.1 to 1–1–36.6.

Mr. President, I so move.

[The motion was duly seconded, was put to a vote and carried.]

Assignment 4—Drainage and Culverts

Chairman Deno: This subcommittee is working on recommended revisions to the part of Chapter 1 of the Manual that relates to subdrains. It is expected that the recommended revisions will be presented to the Association at the March 1966 meeting. W. M. Dowdy, division engineer, Chesapeake & Ohio Railway, is chairman of this subcommittee. Mr. Dowdy, will you stand and be recognized?

Assignment 5—Specification for Pipelines For Conveying Flammable and Non-flammable Substances

Chairman Deno: A. J. Wegmann, assistant engineer structures, construction and maintenance, Baltimore & Ohio Railroad, is chairman of this subcommittee and will present the report.

A. J. Wegmann: President Burris, Chairman Deno, members and guests.

Study and consideration of minor items of revision of the completely rewritten and approved Specifications for Pipelines for Conveying Flammable and Non-flammable Substances is being conducted by your committee.

Your committee has also been continuously active in its collaboration with the American Society of Civil Engineers' Committee on "Pipeline Crossings of Railroads and Highways." To indicate the progress of the ASCE committee thus far a copy of an "Interim Specification" dated January 1964 was forwarded to all chief engineers of Member Roads under date of July 20, 1964.

At the March 1964 convention reference was made to the tests being promoted by the American Society of Civil Engineers Pipeline Crossing Research Council on simulated uncased pipeline crossings for railroads and highways. Presently the research staff of the AAR Laboratory is cooperating with the Battelle Memorial Institute in the testing of a 24-in-diameter uncased pipe. Actual testing is scheduled to start about May 1st and you are all invited to become acquainted with this research by a visit to the Lab. I would especially urge those engineers in the Chicago area to take this opportunity to observe the testing of the 24-in pipe which will be subjected to various combinations of internal pressures and external loading with the aim of developing a design equation.

In the nature of a general statement, I would report, from a study of information received from the ASCE Research Council on the action of casing pipes which were installed by the boring method under various railroads for measurement observations, that the actual deflection has in no case exceeded 1 percent of the pipe diameter after 5 years of service. The theoretical design deflection was 5 percent.

C. E. Peterson (Santa Fe): I should like to know if the committee has considered the use of plastic pipe in these specifications. This type of pipe is coming into the picture.

Mr. Wegmann: That question has been raised. To date the committee has not progressed the matter. The ASCE committee has also talked about it, but it has been concentrating on developing a specification which would be agreeable to the railroads and the highways, using steel pipe. It has even thought of including aluminum pipe. But we have been holding it at the present time to steel and concrete.

Chairman Deno: You might be interested to know that our Subcommittee on Culverts has undertaken, as a part of its assignment, to investigate the use of plastic pipes. We can bring it into the study on pipeline crossings also.

President Burris: Are there any other remarks from the floor? This is where our meetings become very valuable, gentlemen. Do not hesitate to raise these points. That is what our meetings are for.

If there are no further questions, you may proceed, Mr. Deno.

Assignment 6—Roadway: Formation and Protection

Chairman Deno: G. F. Nigh, division engineer, Norfolk & Western Railway, is chairman of Subcommittee 6 and will present the report.

G. F. Nigh: Your committee calls your attention to a tentative draft of Specifications for the Formation of the Roadway presented as information and intended to replace those now appearing on pages 1–1–8 to 1–1–15, incl., of the Manual. The draft appears in Bulletin 591, pages 537 to 546, incl. Comments and criticisms concerning these specifications are invited. These will be considered by your committee prior to presentation as Manual material in 1966.

Your committee's report on Assignment 6 (a), Roadbed Stabilization, is presented in two parts, and may be found on pages 547 through 558 of Bulletin 591.

Part 1 is a report by the AAR Research Department describing soil stabilization by chemicals. The applications had been made on the Western Pacific and on the Santa Fe.

Part 2 is a report by the AAR Research Department which includes a report of investigations of disturbed track condition at Mesa, Wash., by J. W. Keim and A. B. Berg of the Northern Pacific Railway. The disturbed track condition resulted from water saturated soil due to an irrigation project by the Bureau of Reclamation.

Under Assignment 6 (b), Slope Protection, your committee is preparing a revision of the Manual material on pages 1–1–34 and 1–1–35 for presentation in 1966.

Under Assignment 6 (c), Special Treatments for Subgrade Improvement, your committee is assembling reports of applications of such treatments for its consideration.

Under Assignment 6 (d), Hydraulic Fills, your committee has prepared a tentative draft of recommendations and specifications, for hydraulic fills that is being considered by this committee and by collaborating Committee 25.

Assignment 7—Tunnels

Chairman Deno: K. W. Bradley, design engineer, Denver & Rio Grande Western Railroad, is chairman of this subcommittee and will present the report.

K. W. Bradley: Mr. President, members and guests:

Subcommittee 7—Tunnels, has three assignments: (a) Ventilation, changes necessary for operation of diesel power, (b) Clearances, methods to increase, and (c) methods of open cutting.

Your committee reports on Assignment (c) only. The report covers the excavation of a through cut to replace Messiter Tunnel on the Canadian National Railway, and is submitted as information. It is found on pages 559 through 566 of Bulletin 591.

The report describes the soils engineering and construction problems involved with a cut approximately 500 ft long and 120 ft deep. Of special interest was the removal of 300,000 cu yd of extremely unstable silt and the use of work trains in disposing of the material. Both thorough preliminary investigation and close field supervision by soils engineers is shown to have been of great importance in the successful completion of this project.

The Tunnel Specifications found on pages 1–8–1 through 1–8–5 of the Manual are in the process of complete revision. A draft of these revised specifications has been tentatively approved by Committee 1 and copies have been sent to collaborating committees. It is hoped that the new specifications will be submitted for approval at next year's convention.

Assignment 8—Fences

Chairman Deno: This subcommittee is developing recommendations for revision to the part of the Manual covering snow fences which it expects to present to the Association at the next Annual Meeting. P. G. Martin, district engineer, Union Pacific Railroad, is chairman of this subcommittee. Mr. Martin, will you please stand and be recognized?

Assignment 9—Roadway Signs

Chairman Deno: R. D. Baldwin, system industrial engineer, maintenance of way, Pennsylvania Railroad, is chairman of this subcommittee. Mr. Baldwin was unable to be with us today, so I shall present his report.

Your committee reports on Assignment (b)—Shop Layout for Production of Roadway Signs.

After studying shop layouts used for the production of roadway signs on a number of railroads, a plan was developed, which is outlined in Bulletin 591, pages 566 to 568, incl. This plan is offered as a guide and it should be noted that it can be dimensionally changed to suit local conditions.

The report is offered as information.

Assignment 10—Ballast

Chairman Deno: T. W. Creighton, regional engineer, Canadian Pacific Railway, is chairman of this subcommittee and will present the report.

T. W. Creighton: Mr. President, members and guests:

In Bulletin 584, February 1964, pages 508 to 510, incl., recommended ballast sections and ballast quantity graphs were presented as information with the request that members of the Association offer comments and criticisms. Some were received, and although they covered the same features examined over the long period in which this subject has been under study, they were again reviewed with the same results.

Your committee therefore submits this material for adoption and publication in the Manual. The specific recommendations of your committee are as follows:

Delete Ballast Sections for Single and Multiple Track on Tangents and Curves, Manual pages 1–2–6 to 1–2–12, incl., substituting therefor the ballast sections appearing on pages 509 and 510 and the ballast quantity charts, graphs 1 to 4, incl., following page 510 in Bulletin 584, February, 1964.

Mr. President, I so move.

[The motion was duly seconded, was put to a vote and carried.]

Mr. Creighton: A report on Assignment 10 (b), Special Types of Ballast, covering inspections made in 1964 on asphalt-treated ballast test sections and asphalt-treated bridge decks, appears as information on pages 569 to 575, incl., of Bulletin 591.

This concludes the report of Subcommittee 10, Mr. President.

Assignment 11—Chemical Control of Vegetation

Chairman Deno: D. H. Yazell, engineer of vegetation control, Atchison, Topeka & Santa Fe Railway, is chairman of this subcommittee and will present the report.

D. H. Yazell: Mr. President, members and guests: We present to the Association two reports as information. One is a report on the AAR weed control seminar held in Chicago, October 6–7, 1964. The other is a report on helicopter spraying on railroad right-of-way, compiled at the request of a number of railroads for information. It deals with the advantages, disadvantages, costs and benefits to be derived from the use of the helicopter compared with other methods of vegetation control. Both reports appear in Bulletin 591, February 1965.

Chairman Deno: Now, for its special feature this year, Committee 1 has asked one of its own members to address the Association. This particular member has had an experience recently that I believe is without parallel in the history of railroads on this continent.

All of you will remember the disastrous earthquake which occurred in the State of Alaska just about one year ago. While we have read about this earthquake in the newspapers and trade magazines, many of the problems of interest to us have not been reported in detail. I take great pleasure in presenting to you I. P. Cook, chief engineer of the Alaska Railroad, who will discuss, "1964 Earthquake Damages to the Alaska Railroad."

1964 Earthquake Damages to the Alaska Railroad

By I. P. COOK
Chief Engineer, The Alaska Railroad

Mr. President, members and guests:

After receiving the invitation from Les Deno to speak about the Alaska Good Friday Earthquake of March 27, 1964, and its effects on The Alaska Railroad, I am taking the liberty of making a few general comments, and then shall show a number of slides which graphically portray the resultant destruction to The Alaska Railroad.

The earthquake began like any earth tremor. However, it turned out to be much different. It continued to increase in momentum and violence until it reached its greatest magnitude. It was impossible to stand without holding on to some fixed object. It then subsided somewhat faster than it had increased.

During this interval of 3½ minutes, at least twice as much energy was unleashed as in the earthquake that virtually destroyed San Francisco in 1906. Edward McDermott, director of President Johnson's Office of Emergency Planning said, "The disaster ranks with the most extensive and costly suffered in the history of the United States."

I am certain that had this catastrophe taken place near one of our metropolitan areas, rather than the sparsely populated Alaskan coastal region, our dead would have been counted in the tens of thousands, and the property damage in the tens of billions of dollars. As it was, some 200 people lost their lives, and ¾ of a billion dollars' property damage resulted.

Seismologists reported that the earthquake had a magnitude of 8.6 on the Richter Scale. The ultimate limit on this scale is designated as 8.9. At this upper limit, the earth's structure cannot absorb greater stresses without previous failure having taken place.

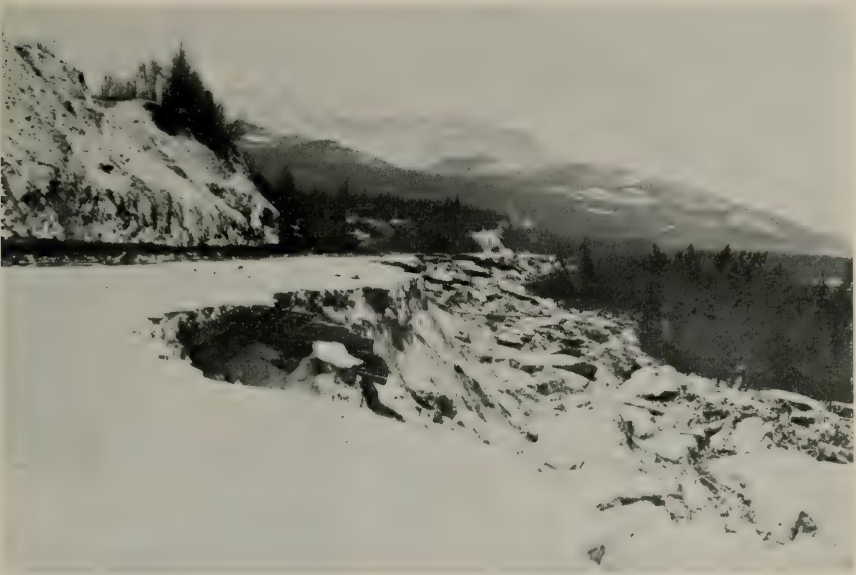
The epicenter, or origin, was in northern Prince William Sound, about 80 miles east of Anchorage, in a region of high, rugged mountains and fjords. Entire mountain ranges covering over 80,000 square miles were uplifted, or subsided, as much as 20 ft.

The initial and greatest shock (and I say "initial" inasmuch as there were following this, some 12,000 lesser aftershocks in the next two months), was felt in varying degrees throughout the world.

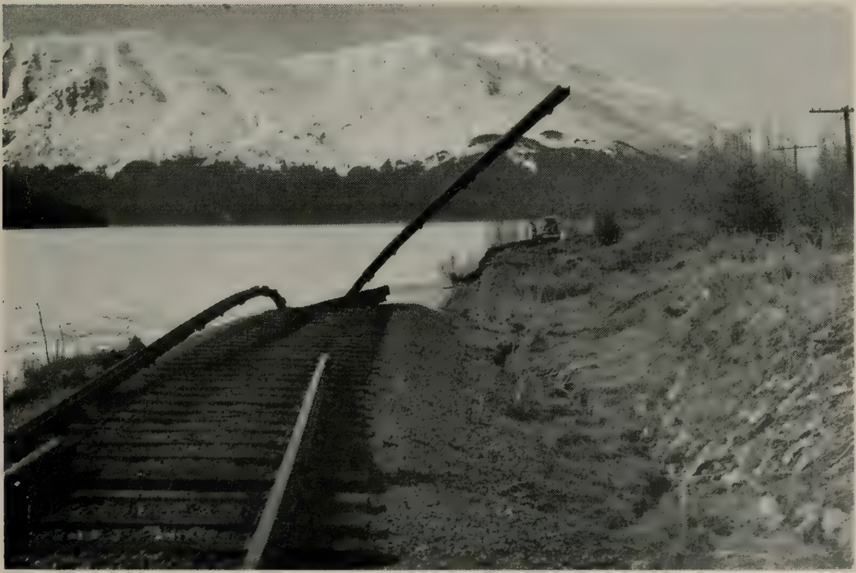
As a result of the displacement of land mass, disastrous tidal waves were generated in the Pacific Ocean which raced in all directions, wiping out entire Alaskan coastal towns, and causing extensive damage and loss of life as far south as California. Tidal waves 8 ft high were generated as far south as the Chilean Coast of South America, and the Orient. In Georgia, well water pumped up and down 10 to 20 ft. Streets in Houston, Tex., bobbed nearly 5 in. A showboat at Vicksburg, Miss. was torn loose from its mooring. One tidal surge in Prince William Sound deposited debris over 170 ft above normal high tide.

The 536-mile Alaska Railroad, which operates from two tidewater ports, namely, Seward and Whittier, on the north Pacific Coast, through to central interior Alaska, suffered intense damage. Some 200 miles of railroad were totally immobilized. All communication with line points was disrupted. The damage was such that it was impossible to use the railroad to reach the distressed areas. Adjacent highways fared no better. To gain access for inspection and to bring in the initial repair crews, extensive use of helicopters was necessary.

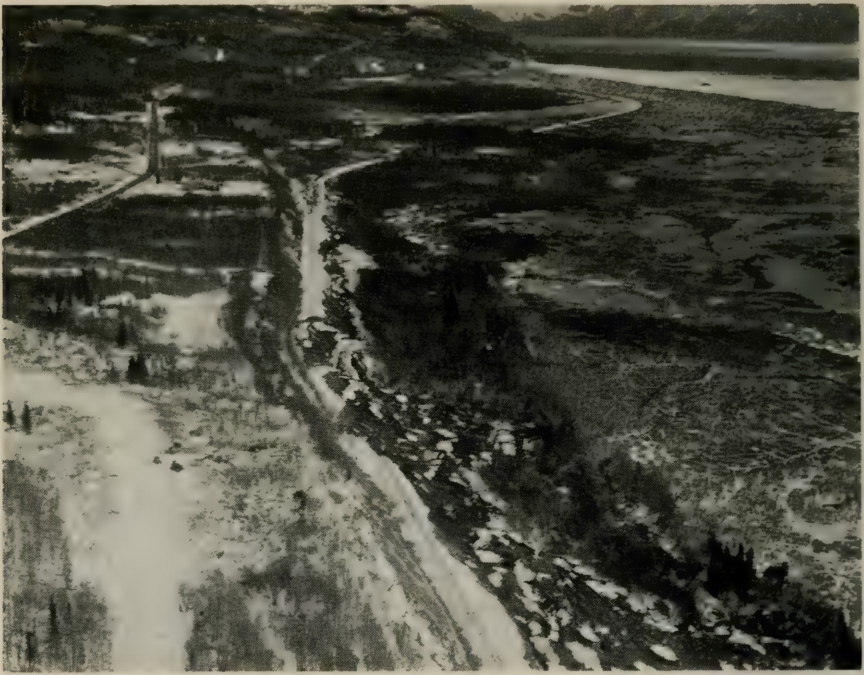
Flights instituted the morning following the disaster revealed that in excess of 110 bridges were rendered unserviceable; miles of track were warped out of line and rails



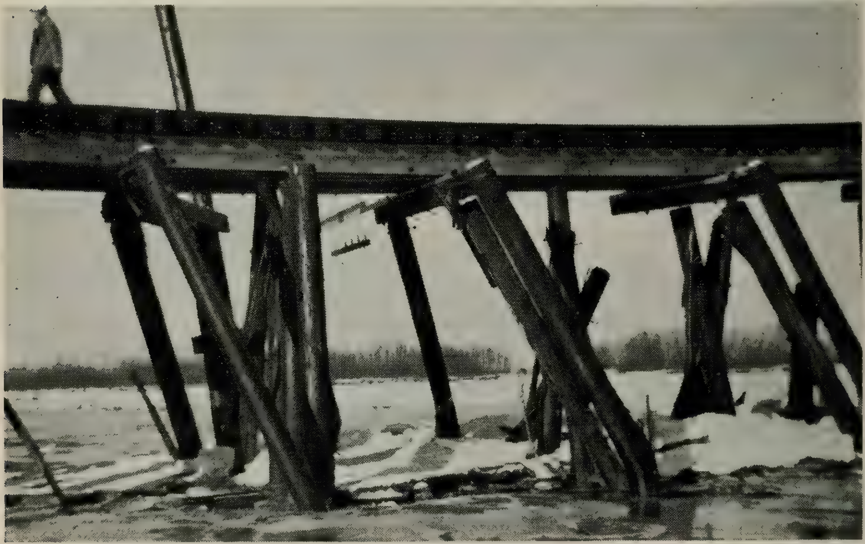
Slides between M. P. 103 and 104 after quake.



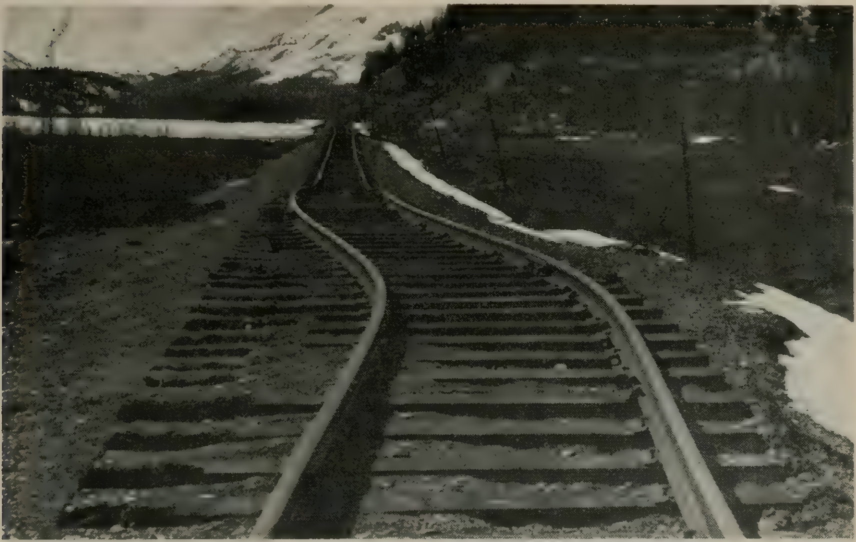
Slide at Kenai Lake.



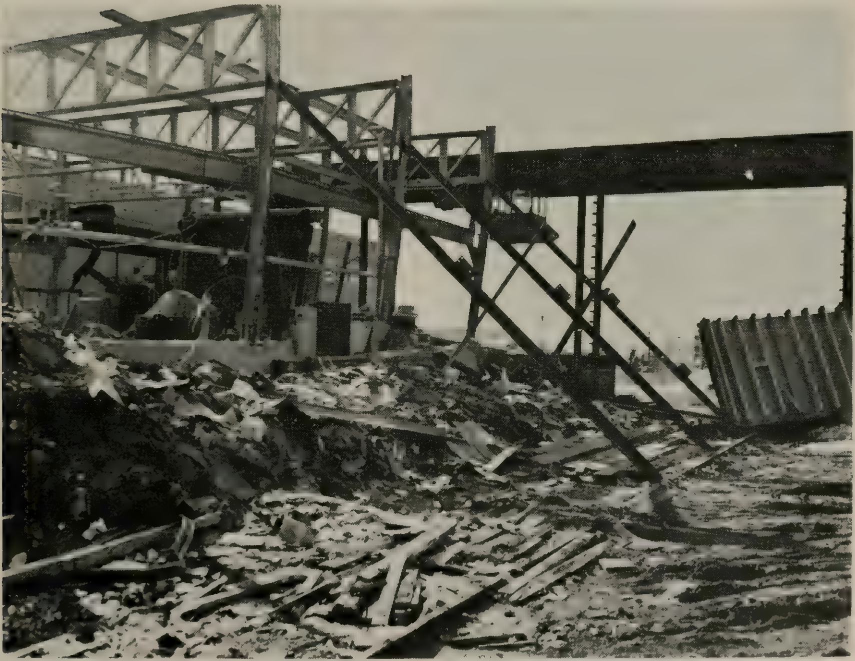
Aerial view of slides between M. P. 103 and 104 after quake.



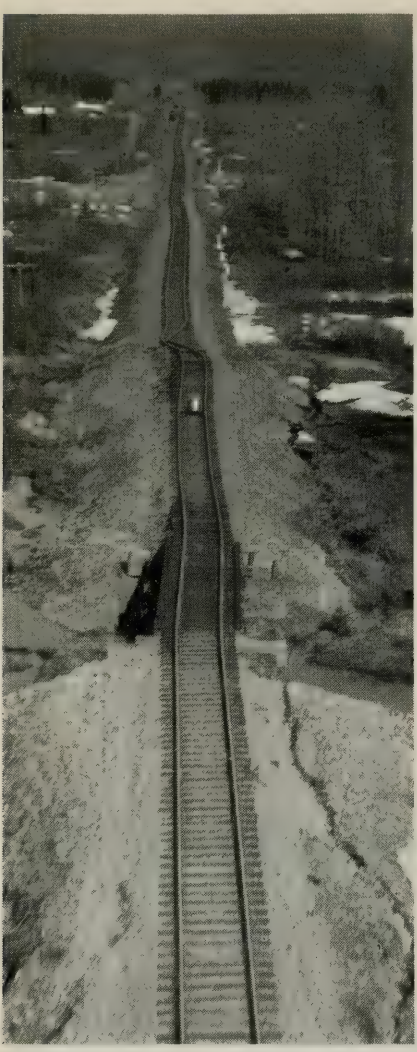
Bridge 140.3 after quake.



Looking south from M. P. 35 after quake.



Quake damage at wheel shop, Anchorage yard.



Looking north from Bridge 62.3.

twisted. Landslides accounted for over 2½ miles of lost grade, leaving rails suspended in mid-air. We found that the port and terminal facilities at Seward were all but wiped out by a combination of seismic action, tidal waves and fire. Our secondary port at Whittier fared somewhat better, but was far from operable. Several major shop and industrial structures were either 100 percent destroyed or required extensive repair at our Anchorage headquarters, and other points. Two hundred and twenty-five pieces of rolling stock were either lost or badly damaged.

In spite of all the damage to property, the most awesome aspect of the earthquake was yet to be realized—the discovery that some 40 miles of roadbed had literally sunk from 4 to 10 ft into the waters of the Pacific Ocean. Such a phenomenon was without precedence in the annals of engineering and railroading. For approximately 40 miles, The Alaska Railroad parallels the waters of Cook Inlet, an estuary of the Pacific Ocean, and had a normal grade freeboard of about 6 ft above flood tides.

Immediately following the quake, we commenced reconstruction of roadway and bridges and had the road open within a few days on a slow-wheeling basis. The high tides of April occurred, and we were amazed to find our railroad in this area inundated by several feet of water and subjected to washouts. Later, oceanographic and geological studies revealed the subsidence of entire mountain ranges by several feet. The railroad is built on a bench in this region, where mountains rise abruptly out of the salt water to an elevation of 5000 ft or more. Where we were not constructed on the benches, we were built on alluvial fans that were underlaid by bedrock of the same origin. Consequently, we settled with the mountain range.

The tides in the Turnagain Arm area in Cook Inlet, have the second highest range in the world. As relocation was impossible in much of the alignment, we were left in an untenable position. Some 3,000,000 cu yd of armor rock and raising material is being brought in to restore trackage to normal freeboard above flood tides and oceanic storms.

The Alaska Railroad is maintained at a high degree of operational efficiency, not only to serve as the main artery for some 200,000 people in central Alaska, but as the connecting link for a number of large military installations, including the Air Force's extensive advance warning network that blankets the sub-arctic region, affording the south 48 states and Canada advance protection and notice in case of enemy aggression.

Being a single stem railroad, we did not have an opportunity to reroute traffic; rather, we had to immediately improvise repairs. Within 9 days after the quake, traffic was rolling to interior Alaska. Thirteen days later, the railroad was opened to our only surviving tidewater terminal of Whittier, and commodities were moving smoothly from West Coast ports of Canada and the United States.

In the short interval of 3½ minutes, $35,000,000 dollars worth of Alaska Railroad property was destroyed.

[Mr. Cook then showed a number of slides, only 7 of which are reproduced herein.]

Chairman Deno: Mr. Cook, on behalf of Committee 1 and the Association, I wish to thank you for your very interesting presentation.

Mr. President, this concludes the report of Committee 1.

President Burris: Thank you, Mr. Deno, for those very interesting and informative reports. The type of work this committee is doing is very important, I believe, at the present time, because most railroads are being asked the question: "What can we do to reduce our costs?" The studies this committee has in progress will help us tremendously to answer this question.

Mr. Cook, we are certainly thankful to you for bringing this interesting talk to us. I suppose a man who has never been in an area subject to earthquakes and who has not experienced these things has little conception of the magnitude of the damage that can be done. Your talk gives us a better knowledge of the trials and tribulations that you people have had.

Again, Mr. Deno, I thank you for a fine performance on the part of your committee. The members of your committee are now excused with the thanks of the Association. (Applause)

Discussion on Rail

[For report, see Bulletin 591, pages 445–494]

President Burris: The second report of this session will be presented by Committee 4—Rail, the chairman of which is J. A. Bunjer, chief engineer, Union Pacific Railroad, Omaha, Neb.

You may proceed, Mr. Bunjer.

Chairman J. A. Bunjer: Mr. President, members of the Association, ladies and guests:

The report of Committee 4—Rail, will be found in Bulletin 591, beginning on page 445.

Before presenting our reports, I should like to take the time to mention to you that we lost three members of our committee through death since our last Convention. They are: William D. Simpson, retired chief engineer, Seaboard Air Line Railroad; Cliff B. Bronson, retired assistant chief engineer, maintenance of way, New York Central System, and a Member Emeritus of Committee 4; and J. L. Gressitt, retired chief engineer, Pennsylvania Railroad, also a Member Emeritus of Committee 4.

A memoir to Mr. Simpson appears in this year's report and memoirs to Messrs. Bronson and Gressitt will appear next year. Their deaths occurred too late to include memoirs in this year's report.

Report of Committee 1

Chairman Bunjer: The chairman of Subcommittee 1 is T. B. Hutcheson, chief engineer, Seaboard Air Line Railroad, and vice chairman of Committee 4. The Manual changes adopted last year made it unnecessary to recommend any at this time. However, I shall ask Mr. Hutcheson to stand and be recognized.

Assignment 2—Collaborate with AISI Technical Committee on Rail and Joint Bars in Research and Other Matters of Mutual Interest

Chairman Bunjer: During the year we held one joint meeting with the AISI at Hershey, Pa., during which we discussed various subjects regarding rail, including service tests and rolling specifications. The joint contact committee meetings with the AISI are extremely worthwhile and beneficial to our various companies.

Subcommittee 2 sponsors the failed rail investigation studies at the AAR Laboratory and report for the year is to be found in Bulletin 591, pages 447 to 453, incl.

Report on Assignment 3—Rail Failures Statistics Covering (a) All Failures, (b) Transverse Fissures, (c) Performance of Control-Cooled Rail

Chairman Bunjer: D. T. Faries, chief engineer, Bessemer & Lake Erie Railroad, is chairman of Subcommittee 3, but he could not be here today. But you will find all of the material that he would have mentioned in the Bulletin. There are no changes that he would comment on at this time.

Report on Assignment 4—Rail End Batter; Causes and Remedies

Chairman Bunjer: R. C. Postels, assistant chief engineer maintenance of way, Soo Line Railroad, is chairman of Subcommittee 4, which has no report this year. I would like to have Mr. Postels stand and be recognized, however.

Report on Assignment 6—Joint Bars; Design, Specifications, Service Tests, Including Insulated Joints and Compromise Joints

Chairman Bunjer: Embert Osland, office engineer, Atchison, Topeka & Santa Fe Railway, is chairman of Subcommittee 6. Mr. Osland.

Embert Osland: The only thing we have to report is that we completed our service test on the North Western and Santa Fe railroads of the various types of bars. The information will be found in the Bulletin.

Report on Assignment 7—Metallurgical Effect of Rail Cropping Methods

Chairman Bunjer: V. E. Hall, assistant engineer, Atchison, Topeka & Santa Fe Railway, is chairman of Subcommittee 7. Mr. Hall, will you stand and be recognized? There is no report by Mr. Hall at this time.

Report on Assignment 8—Causes of Shelly Spots and Head Checks in Rail: Methods For Their Prevention

Chairman Bunjer: C. F. Parvin, engineer maintenance of way, Pennsylvania Railroad, is chairman of Subcommittee 8. Our report on this assigment is subject to a correction by G. M. Magee, director of engineering research, AAR, which will be reported later. There will be a slight revision to the number of cycles to failure in the rolling-load tests described in our report.

Report on Assignment 9—Standardization of Rail Sections

Chairman Bunjer: J. B. Clark, chief engineer, Louisville & Nashville Railroad, is chairman of Subcommittee 9. There will be no report made, other than that which is in the Bulletin. Mr. Clark, will you stand, please?

Report on Assignment 10—Service Performance and Economics of 78-foot Rail, Specifications for 78-foot Rail

Chairman Bunjer: A. P. Talbot, assistant engineer, Pennsylvania Railroad, is chairman of Subcommittee 10, but he could not be here.

Mr. President, this concludes the report of Committee 4.

President Burris: Thank you, Mr. Bunjer, for your committee's report.

I think this is one of the committees which has a big job to do. We are going to have to live with larger and heavier rolling stock, and this heavier rolling stock along with greater speed is going to "raise hob" with our rail. How are we going to make the metal stand up under this additional load? With more and more welded rail in track which we can't take out as readily as jointed rail, we have to have rail that will stand up.

This committee has its work cut out for it. I think it has men who are capable of carrying it out.

Mr. Bunjer, I want to thank you for this report. Your committee is excused with the thanks of the Association. (Applause)

Discussion on Continuous Welded Rail

[For report see Bulletin 591, pages 507-520]

President Burris: Next on the program is the youngest standing technical committee in the Association, formerly the Special Committee on Continuous Welded Rail, now Committee 31. It was granted permanent status on November 6, 1964, by action of the Board of Direction. The first chairman of the new standing committee is W. J. Jones, engineer maintenance of way and structures, system, Southern Pacific Company, San Francisco, Calif. Mr. Jones, will you proceed?

Chairman W. J. Jones: Mr. Chairman, members of the Association and guests:

The report of Committee 31—Continuous Welded Rail, appears in Bulletin 591, on pages 507 to 520, incl. Your committee reports on its six assignments.

Assignment 1—Fabrication

Chairman Jones: The report of Assignment 1 is presented in three parts, all as information. Part 1 is a progress report on the development of specifications for fabricating continuous welded rail. Before drafting a set of recommended alignment and finishing tolerances for fabricating continuous welded rail, your committee had to determine to its satisfaction that rail as furnished by rail rolling mills would meet normal butt-welding requirements. Your committee joined with Committee 4—Rail, on a Task Committee which visited the five rail rolling mills in the United States, and reviewed rail rolling practices. It is the opinion of the Task Committee that rail suitable for butt-welding can be produced under the current Specifications for Open-Hearth Steel Rails (Basic-Oxygen Process May Be Used at the Option of the Purchaser), Chapter 4, of the Manual, and that no change in these specifications is required for the present. With this finding your committee is now in position to develop Manual material.

Part 2 covers the examination of service and detected failures of butt-welded rail joints. Part 3 furnishes the results of rolling-load and slow-bend tests of butt-welded rail joints. Parts 2 and 3 were prepared at the AAR Research Center.

Assignment 2—Laying

Chairman Jones: The report on Assignment 2 is presented in two parts. Part 1 reports progress on the development of recommended practices for the laying of continuous welded rail. Your committee has accumulated considerable data and has made some analysis of the problems. It is expected that the study will be completed and recommended practices for laying continuous welded rail drawn up and offered for adoption and publication in the Manual next year.

Part 2 is a statistical story which relates in unmistakable manner the spectacular growth in the use of continuous welded rail on our railroads from 1933 to 1964. From a look at the statement on page 517, Bulletin 591, it is seen that more miles of continuous welded rail was laid in 1964 than in all the years together prior to 1959. Also of interest is the fact that the miles of continuous welded secondhand rail laid last year almost equal that of new rail.

Assignment 3—Fastenings

Chairman Jones: Last year your committee reported on its study of rail anchorage patterns for continuous welded rail. It was concluded that current practice does not support a revision of the rail anchorage pattern now appearing on page 5–5–4.2 of the Manual.

Your committee has advice that some difficulties are being experienced with continuous welded rail. Replying to a questionnaire circulated among committee members, six roads reported trouble with line kinks, nine with pull-aparts, and six reported having cut and adjusted rail after it had been laid.

Your committee recognizes the need for supplementing our present knowledge of anchorage for continuous welded rail but is unable to propose any changes until more scientific data are available from field tests, including installations with different numbers of ties anchored, different types of ballast and determinations of proper temperature ranges for laying or adjusting continuous welded rail. This subject will receive further study.

Assignment 4—Maintenance

Chairman Jones: Your committee has completed its review of the tentative new ballast sections and ballast quantity graphs appearing in Bulletin 584, Vol. 65, page 508, in order to determine if any change should be made in these sections to accommodate continuous welded rail.

Your committee recommends that the following revisions be made in tentative new ballast sections:

(1) For CWR a full ballast section should be provided, i.e., to the top of the ties instead of 1 in below.

(2) Six-inch shoulder berms should be provided beyond the ends of the ties both on tangent track and the high side of curved track. Different ballast sections for tangents and curves are not compatible with mechanical ballast distributing operations. It is the consensus that the additional ballast in excess of 6 in beyond the tie ends is of little or no benefit in preventing alignment irregularities or buckled track.

Assignment 5—Economics

Chairman Jones: It might seem obvious that multi-tier trains offer greater economies than single-tier trains in transporting continuous welded rail. However, as definite figures have not been published on this subject, your committee is making a study and expects to report thereon next year.

Assignment 6—Welding Secondhand Rail

Chairman Jones: The use of secondhand rail in the continuous welded rail programs of many railroads is increasing. Some railroads weld as much or more secondhand rail than new. This is true because of the greater availability of secondhand rail and the economy to be realized through its use. The economies to be realized vary among railroads according to the method of rail recovery, cost of handling through the reclamation plant and class of rail available.

It is suggested that the following prerequisites be observed if one hopes to obtain optimum benefits from welding secondhand rail:

(1) Handle the rail in such a manner as to keep it in the original sequence.
(2) Plant test the rail by ultrasonic or equal method.
(3) Perform vertical and horizontal straightening of rail as may be required, prior to welding.
(4) Remove excessive overflow metal from ball of rail.
(5) Repair and/or build up minor wheel burns.
(6) Grind out surface irregularities immediately after rail is laid.

The loss of rail involved in cropping and welding secondhand rail varies from 12 to 15 percent. Where it is desired to improve rail conditions on a line and not increase the rail section, one train load of new rail can be laid. The rail released can be welded and returned to the track. This process can be repeated several times, producing as much as 5.5 miles of welded secondhand rail for each mile of new rail used. The use of secondhand rail in continuous welded rail programs will permit the use of welded rail by railroads which are unable to purchase a sufficient amount of new rail to generate a realistic program. This is presented as information.

Chairman Jones: I should now like to introduce the chairmen of the subcommittees. Will each please stand in turn to be recognized as his name is called?

A. H. Galbraith, welding engineer, Atchison, Topeka & Santa Fe, chairman, Subcommittee 1.

O. E. Fort, chief engineer, Frisco, chairman, Subcommittee 2.

R. E. Frame, assistant chief engineer, Southern Pacific Company, Texas and Louisiana Lines, chairman, Subcommittee 3.

J. R. Rymer, division engineer, Baltimore & Ohio, chairman, Subcommittee 4.

T. C. Shedd, Editor of "Modern Railroads," chairman, Subcommittee 5.

J. F. Beaver, chief engineer, retired, Southern Railway, chairman, Subcommittee 6.

Mr. President, the close of this Convention also brings to an end my term as chairman of Committee 31—Continuous Welded Rail. I wish to express my appreciation to the members of our committee and particularly to the chairmen of the subcommittees for their cooperation and support. I publicly acknowledge the valuable assistance given us on our committee by the executive secretary's office. This assistance, I am sure, will improve the quality of the reports in the future.

Our new vice chairman on Committee 31 is H. C. Fox, assistant chief engineer, Southern Railway. Mr. Fox was in attendance at the Convention earlier, but he, too, had to leave.

Your new chairman of Committee 31—Continuous Welded Rail, is C. W. Wagner, engineer of tests, Canadian National Railways. Mr. Wagner is a very able man, and I am sure that under his guidance this committee's work will greatly improve in the future. Mr. Wagner, will you please stand? [Applause]

Mr. President, this concludes the report of our committee.

President Burris: Are there any questions?

G. M. Magee [AAR]: I would like to comment, if I may, in connection with the committee's recommendations in regard to the ballast sections developed by Committee 1. This may be something the committee has already taken into account, but we had occasion to notice in one of our service tests that we conducted on the Illinois Central, where we had asphalt-coated ballast and had occasion to observe the performance of the track very closely, that there was a quite definite and noticeable tendency for the track to settle in the ballast after it had been surfaced up, particularly if it is given any appreciable raise in connection with the surface.

If, when you resurface track, you give it a substantial lift, and dress your ballast to the top of the tie, the track may settle down to where you have the ballast above the top of the tie; so actually you would waste ballast and also have what might be considered a somewhat undesirable condition—having your tie plates and spikes covered with ballast.

I merely wanted to throw that into the hopper for consideration.

President Burris: Does anyone else in the audience wish to comment? If not, I want to thank Mr. Jones and his committee for their excellent report.

Mr. Jones, we appreciate the able and dedicated leadership which you have given Committee 31 during the past three years. As you are relieved of your responsibilities as chairman, we are pleased to welcome your successor, Mr. Wagner, and the new vice chairman, Mr. Fox. We are satisfied from their past performance and qualifications that under their direction the good work of your committee will continue.

Mr. Wagner, as a symbol of your new authority and to assist you in conducting the meetings of your committee, I would like to present you with this chairman's gavel, the inscription on which reads: C. W. Wagner, Chairman, AREA Committee 31, 1965–67. (Applause)

Mr. Jones, your committee is excused with the thanks of the Association.

Discussion on Track

[For report see Bulletin 591, pages 495–506]

President Burris: The final committee to report to this Convention is Committee 5—Track, the chairman of which is J. M. Salmon, Jr., chief engineer, Clinchfield Railroad, Erwin, Tenn. Mr. Salmon, the microphone is yours.

Chairman J. M. Salmon, Jr.: Mr. President, members and guests of the AREA: it is with sincere regret that I must report the passing of two faithful and long-time members of this committee—Stewart J. Watson, who died on July 15, 1964, and Carl H. Johnson, who died on December 23, 1964. A memoir to Mr. Watson appears on page 497 of Bulletin 591. An appropriate memoir to Mr. Johnson will appear in the next report of this committee.

The report of the Track committee will be found in Bulletin 591 of February 1965. To conserve time and avoid repetition of printed matter, which I am sure all who are interested have read, I shall call only upon the subcommittee chairmen whose subcommittees are able to report on their assignments. Because I do not call upon all the subcommittee chairmen does not mean that some have not worked. All have carried out their responsibilities in high degree, and I want to take this opportunity to thank each of them.

Assignment 1—Revision of Manual

Chairman Salmon: Assignment 1 will be reported on by Subcommittee Chairman R. J. Hollingsworth, engineer materials—track, Baltimore & Ohio Railroad.

R. J. Hollingsworth: Your committee submits for adoption an addition to the Specifications for High Carbon Steel Track Spikes to provide for an alternate when ladle analysis cannot be furnished, similar to the one provided for in the Specifications for Soft Steel Track Spikes.

The specific recommendations of your committee are printed on page 498 of Bulletin 591, and I move that they be adopted.

[The motion was duly seconded, was put to a vote and carried.]

Assignment 2—Track Tools

Chairman Salmon: Assignment 2 will be reported on by T. L. Biggar, general supervisor of track, Chesapeake & Ohio Railway.

T. L. Biggar: A complete report of the activities of Subcommittee 2 may be found on page 498, Bulletin 591, February 1965.

A study was made to establish the saving that could be experienced by repairing track tools in a railroad's own shop or reclamation plant. It was found that a 69.5 percent saving is possible, depending on quantity repaired.

A combination track level and gage made of cast aluminum has been designed and approved. This will be reported on next year.

Assignment 3—Standardization of Trackwork Plans

Chairman Salmon: Assignment 3 will be reported on by Subcommittee Chairman C. J. McConaughy, track designer, Southern Pacific Company.

C. J. McConaughy: Mr. President, ladies and gentlemen:

Subcommittee 3 has published its report in Bulletin 591, and I assume most of you have reviewed it.

In keeping with our past practice of maintaining up to date the plans in back of the blue divider sheet in the Portfolio of Trackwork Plans, your committee recommends that Plans No. 405–55, No. 10 Spring Rail Frog, Short Spring Rail Type, and Plan

No. 408–55, No. 9, No. 11 and No. 12 Spring Rail Frogs, Short Spring Rail Type, both be removed from the Portfolio, also the deletion on Plan 490–55, Diagram Illustrating Preferred Names of Parts for Spring Rail Frogs, of the drawing of the short spring-rail type.

Mr. President, I move that the elimination of Plans 405–55, 408–55 and deletion of a portion of Plan 490–55 be approved.

[The motion was duly seconded, was put to a vote and carried.]

Mr. McConaughy: Appendix A–59, page 3, Article 405, of the Trackwork Portfolio covering Physical Requirements and Tests of manganese steel castings is recommended for revision to clarify how the test bar is to be bent. This revision conforms to the wording in the ASTM Standard, 1964, Part 2, Ferrous Castings, which reads as follows: "7 (b) When bend tests are specified, the test specimens shall stand being bent cold through 150 deg without breaking around a pin 1 in. in diameter. The specimen may be bent in any method preferred by the manufacturer."

Mr. President, I move that the recommended revision to Article 405 be adopted.

[The motion was duly seconded, was put to a vote and carried.]

Mr. McConaughy: Study of Plans 15–62, sheet 1 and 20–62, sheet 1, covering the tie layouts for the crossovers, has been reviewed, and at this time it appears that they should be revised to provide an arrangement for the various tie lengths similar to that shown on Plan 912–58. This change should avoid difficulty in maintaining gage through the crossover under the heavier wheel loads and higher permissible speeds now in effect. The revisions will be presentd for adoption in 1966.

Plan 820–50, Graph Showing Limitations for the Use of Crossings with Rigid Center Frogs, permits the use of rigid center frogs in tangent crossings with angles of 9 deg 30 min to 8 deg 10 min in yards and terminals. Investigation of this matter has developed that rigid center frogs of angles less than 9 deg 30 min can create a hazardous condition. A report on this matter will be ready for submission in 1966.

Plan 775–55, Crossings with Solid Manganese Steel Frogs—Angles 14 Deg 15 Min to 8 Deg 10 Min, was found to be in error in not having been revised to conform to Plan 774–55, covering crossings of larger angles and Note 5 on Plan 820–50, both of which plans call for 1⅞-in parallel flangeways. Plan 775–55 will be corrected to show parallel flangeways 1⅞ in wide, the same as the other plans. Revision of Plan 820–50 as previously mentioned will also affect Plan 775–55 with respect to the minimum permissible angle for rigid center frogs.

Your committee has investigated the problem of broken bolts caused by the heads separating from the shanks. In practically all cases there was evidence of a fracture or shrinkage crack due to the lack of a fillet radius on the shank under the bolt head. We wish to report that the American Standards Association is revising its Specification ASA B–18.2 to include a definite radius under the head of the bolts for the various diameters. The specification for bolts in the Trackwork Plans Portfolio, Appendix A, Section 1402, reads: "Heads—American Standard regular square heads (ASA B–18.2–1941), or any later revision thereof, except where otherwise shown on detail plans." Therefore, no change is required in our specification.

Work is continuing on Assignment 3 (a). No comparison is possible at this time because it appears that there are no records available, nor have studies of this nature been made by any of the railroads. Your committee will continue to explore this matter further and have a recommendation for the 1966 Convention.

Assignment 3 (b) has been requested to be discontinued. The spring rail, the railbound manganese and the self-guarded manganese frogs are designed for different and separate uses; therefore, it is not considered practicable to make a meaningful comparison. Your committee is working on a suggested recommendation for the desirable use of the various frogs that could be accepted as Manual material.

Assignment 3 (c) is being progressed. It has been expanded to include all types of track expansion rails, and the committee hopes that from its study Manual material can be developed. This assignment covers a wide spread in use, location and physical requirements.

Mr. President, that completes the report of Subcommittee 3.

Assignment 8—Laying Rail Tight with Frozen Joints

Chairman Salmon: Assignment 8 will be reported on by S. H. Poore, office engineer, Chesapeake & Ohio Railway.

S. H. Poore: The report of this subcommittee appears beginning on page 500 of Bulletin 591.

Test installations of tight rail was started in November 1953 on the L&N and in 1957 on the Erie and the B&LE. Field observations on these installations do not show any significant difference between tight rail and rail laid with conventional bolted joints with the usual amount of expansion gap. It appears to this committee, therefore, that there is no point in carrying this test further, and it is suggested that this subject be dropped.

Assignment 9—Critical Review of the Subject of Speed on Curves as Affected by Present-Day Equipment, Collaborating with the AAR Joint Committee on Relation Between Track and Equipment

Chairman Salmon: Assignment 9 will be reported on by Subcommittee Chairman L. W. Green, resident engineer, Pennsylvania Railroad.

L. W. Green: Mr. President and gentlemen:

Subcommittee 9 has completed a rather lengthy study as to the desirability of revising the formula now shown in the Manual of Recommended Practice for determining the length of spirals. Preliminary discussions of this study were published in Bulletin 580, September–October 1963, and again in Bulletin 584, February 1964.

In Bulletin 591, February 1965, pages 501 to 503, there is shown the final results of this study and our recommendations.

It is proposed to delete Art. 1—Purpose, on page 5–3–1 of the Manual of Recommended Practice, substituting therefor the material shown in Bulletin 591, pages 502 and 503.

Mr. President I move that this recommendation be adopted.

[The motion was duly seconded, was put to a vote and carried.]

L. W. Green: Your committee is working with the Joint Committee on Relation Between Track and Equipment, AAR, on its other assignment, "Special Requirements of Track Construction and Maintenance Due to Operation of Equipment with High Center of Gravity and/or Hydraulically Cushioned Underframes" and will present a report at some future date.

Assignment 10—Methods of Heat Treatment, Including Flame Hardening, of Bolted Rail Frogs and Split Switches, Together with Methods of Repair by Welding; Explosive Hardening of Manganese Steel Trackwork

Chairman Salmon: Assignment 10 has been in the good hands of H. W. Jensen, who retired recently as maintenance engineer of the North Western. Mr. Jensen was unable to be here today, so his report will be given by S. H. Poore, office engineer, Chesapeake & Ohio Railway, who will be chairman of this subcommittee for the coming year.

S. H. Poore: This subject was assigned in 1953. As some members may recall, three 39-ft panels, embracing 24 simulated crossing intersections, was installed in 1954 on the Milwaukee Road near Mannheim, Ill. Each of these panels contained three sections of flame-hardened rail and three sections of completely heat-treated rail. There also was included a section of used chrome-vanadium rail. Control panels of open-hearth control-cooled rail were also included. Discussion of these panels appear in Vol. 57 of the Proceedings, page 769.

Inspections of these panels were made periodically by the AAR research staff. The wear measurements taken are reported in subsequent volumes of the Proceedings.

In 1957, after these panels had carried substantially 90 million tons of traffic, repair operations were undertaken with various welding techniques. The repaired panels were watched closely until September 1963, at which time it was judged that sufficient data had been accumulated and the panels were taken out of service. A total of 299 million tons of traffic had been over them to this date.

The large amount of data accumulated during this 9-year period is now being reduced and will be published as an engineering research report. It is the hope of your committee that we will be able to develop and present for your considration specifications for repair of this type of trackwork by welding.

Assignment 11—Practicability of Using Reflex Units For Switch Lamps and Targets

Chairman Salmon: Assignment 11 will be reported on by A. B. Hillman, Jr., chief engineer, Belt Railway Company of Chicago.

A. B. Hillman, Jr.: This committee's progress report is presented as information on pages 504 through 506 of Bulletin 591.

The report gives annual cost data for reflex lenses versus oil lamps and electric lamps. The savings to be realized though the use of reflex lenses indicates their practicability.

The report gives the positions of 19 states with respect to the use of reflex units. Your committee will continue the study to determine the positions of other states.

Chairman Salmon: It has been a little frustrating to attempt to progress or conclude assignments in which research was involved and funds were not budgeted. Your committee expects, funds being available, to conclude one or more of our 1964 assignments in 1965 and to present Manual material at the 1966 Convention.

Mr. President, this concludes the report of Committee 5—Track.

Now, as a special feature, it is my pleasure to moderate a panel composed of distinguished engineers who will discuss "Standardization: Its Progress, Its Pitfalls, Who Is Using and of Those Members Not Using—Why Not?"

Panel Discussion—Standardization: Its Progress, Its Pitfalls, Who Is Using, and of Those Members Not Using, Why Not?

Chairman Salmon: The panel members are, in alphabetical order:

C. J. Code, assistant chief engineer, Pennsylvania Railroad;

K. H. von Kampen, chief engineer, Pettibone Mulliken Corp., who will speak as president of the Manganese Track Society and chairman of its Engineering Section;

H. M. Williamson, chief engineer—system, Southern Pacific Company; and

F. R. Woolford, chief engineer, Western Pacific Railroad.

In the event Mr. von Kampen is presented questions upon which he desires to collaborate, he will be assisted by M. J. Hassan of Taylor–Wharton and O. F. Magnus of American Brake Shoe Company.

Standardization is a must in all industry. Our complex industrial society of today, with its ever-increasing automation, demands standardization. Your Association deals with engineering and technical problems, its committees are made up of railroad, university and supplier members who deal almost entirely with the engineering and technical problems of the railroad industry. The AREA Manual of Recommended Practice is in itself a compilation of standards.

These standardization efforts must be credited over the years with increasing safety, simplifying maintenance and logistics problems and reducing capital and operating expenses. They have been arrived at as the best engineering solution to a common problem, not bound to the special interests of any individual railroad or any manufacturer.

The Manual of Recommended Practice of this Association is available to anyone for voluntary use or acceptance. There is no obligation on the part of any company, government agency or individual to use our standards. We are in no position to select or recommend the use of any item manufactured by a specific manufacturer; neither do we become involved in vendor–customer relations and similar activities not directly or completely involving engineering consideration; nor do we impinge on the design or proprietary prerogatives of a manufacturer.

The generation of standards and their promotion for general acceptance should be a primary activity of this Association. This panel will endeavor to present to you this morning answers to questions relating to standardization.

In approaching this problem for discussion, I am calling first on Mr. von Kampen. This is not to be construed in any way as putting those he represents on the spot, so to speak, but to clear up any possible misunderstanding and to let those who are responsible for actual manufacture of products to our standards answer some of the many questions which are in all of our minds.

Mr. von Kampen, realizing at the present time that there are some 30 rail sections with varying end drillings in use and that the AREA has currently six adopted rail sections, do you find that manufacturers can or do make price concessions to the purchasers of turnout materials when ordered to the 1962 standard AREA plans?

K. H. VON KAMPEN: The frog and switch manufacturers make no price concessions to purchasers of turnout materals to 1962 AREA standard plans. But they will make price reductions for purchasers of turnout components if a sufficient volume is ordered that would warrant reductions by reason of savings occurring in manufacturing.

Such reductions cannot readily be realized today because, as you have already mentioned, of the great number of rail sections involved, and the variations in the joint drillings in each rail section and in the numbers of turnouts required. Adoption of AREA standards by the majority of railways could produce sufficient volume of turnout components to justify price reduction, but it is not now possible due to these variations in individual railroad specifications and the special nature of the trackwork components.

CHAIRMAN SALMON: Mr. von Kampen, you have shown that at least for the present no price concession as such is forth coming simply because the 1962 standard plans are used. Does the manufacturer in turn penalize or increase the price to users of non-standard items?

Mr. von Kampen: No penalties are placed on any purchaser of non-standard items. Ours is and always has been a specialty business due to the variations previously mentioned.

Chairman Salmon: Mr. von Kampen, is there a line drawn by the manufacturer between standard and non-standard items of trackwork?

Mr. von Kampen: Manufacturers of turnout materials can draw no line between standard and nonstandard items, as we always have and always will stand ready to manufacture turnout items desired by all purchasers at a fair and equitable price.

Chairman Salmon: Mr. Code, as I understand Mr. von Kampen, the quantity purchased of any one item has far more to do with cost to the purchaser than any particular standard. What concessions, if any, have you been able to obtain on price, stocking, etc.

C. J. Code: I think our experience corresponds pretty much with what Mr. von Kampen has told you. As far as I can find out, we have not been able to obtain any concessions on price due to adopting standard plans.

A year-and-a-half ago we adopted the AREA 115-lb turnouts for use in industrial tracks and yard tracks. Since that time we have been buying them in considerable quantity. I have checked with our purchasing agent, and he tells me that we do get some concessions in stocking. That is, the manufacturers are willing to stock certain frogs and switches which are purchased in considerable quantity, permitting us to reduce our inventory.

However, I find that that also applies to our own 140-lb material, which is made to our own standards and not to AREA standards.

Chairman Salmon: Mr. Code, I understand that almost all of your working life has been spent on the Pennsylvania Railroad. I recall a prominent Pennsylvania slogan: "The Standard Railroad of the World." You therefore have been working with standards for probably more years than you would like to divulge. If you find that standard design is in some respect inadequate for your situation, what do you do about it?

Mr. Code: I would like to comment, if I may, on your preamble. (Laughter) We did have a slogan many years ago that we were the standard railroad of the world. We gave it up. I think we gave it up because we thought it was rather offensive.

I remember thinking when I was a young engineer on the Pennsylvania Railroad, trying to learn something about standards, that you could say we were the standard railroad of the world because we had more standards than any other railroad in the world. (Laughter)

When I started in—and I am perfectly willing to admit that I have been working for the Pennsylvania Railroad 45 years, since about 1920—we had just consolidated Lines East and Lines West. We had a Lines West standard-plans book, which was an inch thick, and we had a Lines East standard-plans book, which was also an inch thick, and we had a new Systems standard-plans book, which was at that time about a half inch thick and getting thicker by the minute.

You might say I spent my first 5 years learning standards, the next 15 years applying them, and the last 20 or 25 years testing and adjusting them and having something to do with developing standards myself.

Certainly we find that standards have to be changed and kept up to date. If we find that a standard design is not adequate for our situation, whether it is our own design or an AREA design, we change it to suit the situation.

Chairman Salmon: Mr. Code, do you find that necessary changes in standards can be processed quickly enough, particularly with respect to AREA plans, to accommodate your situation?

Mr. Code: Of course, if we make the changes ourselves, you might say unilaterally —and that is what we have had to do in a few cases—there is no particular problem introduced. But I think if we attempted to get the AREA to adopt some of the minor changes that we have made, we might have a little difficulty. It might take some years to do it and maybe it wouldn't get done at all.

Actually, the changes that we have found necessary to make so far in the use of the 115—AREA material are minor in character and do not affect the basic material that we purchase.

We require a slight change in the spacing of the holes and drilling for the switch rods, which is no particular problem; and we have found that we do not like the arrangement of joints in the AREA turnout because of too many joints coming on one tie, and we made a change in that. But we have not found it necessary to make any changes in the switches and frogs.

Chairman Salmon: Mr. Williamson, the 1962 standard plans reduce the number of recommended turnouts from some 26 to 5, with no alternates of construction. Is it your opinion that these plans do not cover the economical needs of all railroads?

H. M. Williamson: I believe that the five plans would cover practically all of the needs, Mr. Chairman. There will, of course, always be exceptions.

I am sure the manufacturers stand ready to make any special design. It probably will be some time before all the railroads will standardize on these five turnouts; but I think we are making progress in this area. This is the direction we should be taking.

Chairman Salmon: Mr. Williamson, could standardization be detrimental to the railroads by restricting improvements, changes in design or competition?

Mr. Williamson: No. I think not. There will be delays in getting adoption of new standards; there always will be. But in the interim, special concessions can be made. I think if we are actively behind these standards, we can get new designs and new products that we find to be necessary approved, standardized and put in our Manual in a shorter time.

Chairman Salmon: Mr. Woolford, some years ago I believe you were active in a group of far western railroads that were working toward a set of standards so that track materials, particularly turnouts, would be interchangeable. How do you feel that standardization would benefit the railroads?

F. R. Woolford: I think standardization would benefit the railroads in many different ways. First, it would reduce the store stock of individual railroads. That was one of our main purposes in trying to standardize in the West. With several railroads close together, we figured we could borrow from each other, and no railroad would have to carry the entire stock needed on its property.

Secondly, it would certainly reduce the cost of our materials. Since coming to this Convention, I have had the opportunity to talk to a man from one of the major manufacturers of track materials—and he is a man that makes them, not a man that prices them—and he assured me that he was certain that if standardization were a reality on the American railroads, prices would be reduced at least 25 percent.

I questioned this figure, and he said he was certain that it was correct. He could make a 25 percent reduction in cost if he could use the idle time and stockpile the materials, knowing that they would be ordered as the railroads needed them.

On my railroad, and I know the others must endure the same thing, when we want a frog, or switch points, or other parts of a turnout, we have to allow at least 30 days and often a 90-day lead time. That delays our own projects. It delays industries that are anxious to go ahead. And these delays are costly.

The fourth item, I think, is this: by having standard plans, the railroads would get closer together. It would get the designers closer together, interchanging ideas and thoughts in regard to the various accessories used by the railroads.

Chairman Salmon: Mr. Woolford, do you think that standardization will ever be adopted by all American railroads?

Mr. Woolford: Yes, I do. I think it is bound to come. One thing that has held us up so long in adopting standardization is the individuality of the track designer. We have many that are jealous of their designs and do not want to give way.

I ran into this quite extensively when we tried to standardize three western carriers. I thought I had put it over but the Western Pacific was the only one that accepted the final design of the standards. So we were unsuccessful in standardizing these Western lines.

Chairman Salmon: Mr. von Kampen, since you manufacturers feel the pulse, so to speak, of the purchasing of special track materials, can you say how many railroads are using the 1962 trackwork plans?

Mr. von Kampen: Mr. Chairman, I cannot definitely say how many railroads are now purchasing to the 1962 AREA standard turnout plans, but they are very few, and in most cases, they specify certain exceptions and modifications to those plans.

Chairman Salmon: Mr. von Kampen, from your experience, could standardization be detrimental by restricting improvements, changes in design and possibly competition?

Mr. von Kampen: Standardization could be detrimental. However, the AREA policy of constantly reviewing the standard plans and adopting improvements in design, and so on, when new methods or materials come into the picture, can alleviate this problem. To this might I add a quotation taken in part from an editorial in the magazine *Steel* of March 1, 1965, which was headed "Overstandardization Assailed,"

"Too much standardization can rob the nation of its initiative, its creativity, its curiosity, its healthy discontent with the way things are, all of which are essential to progress."

Chairman Salmon: Mr. von Kampen, to what extent does the industry stock frogs, switches and guard rails?

Mr. von Kampen: The frog and switch manufacturers do not stock standard turnout components as such, but do carry in stock various parts for these items, including certain castings, rail, plates, bars, joint bars and other materials necessary for their operations.

Chairman Salmon: Mr. Code, do you find you must make changes in details after you have adopted standards and, if so, do such changes defeat the purpose of standardization?

Mr. Code: We certainly do have to make changes, but I do not feel that this defeats the purpose of standardization. I think, as someone else has pointed out, standards have to be more or less fluid. You have to keep revising them and keeping them up to date. I certainly do not think that defeats standardization.

Chairman Salmon: Mr. Woolford, in your opinion, has standardization been progressed further in other areas of railroad maintenance and construction than it has in the field of special trackwork?

Mr. Woolford: Yes. I think it has. We use the AREA recommendations. I am quite certain that other railroads use them too, particularly the specifications covering such items as rail, spikes, bolts, tie plates, ballast, creosoting of timbers, etc. But I must again mention that I think the big drawback in our adopting standards in special trackwork is the pride of design of the individual track designer.

Chairman Salmon: Mr. Woolford, have you any other opinion as to why standardization has been so slow in being accepted by railroad engineers?

Mr. Woolford: Well, I shall have to go back to the item I have mentioned a couple of times—it is the pride of design of the individual track designer that has kept us from standardization of frogs, switches and turnout assemblies. I think standardization will come eventually but it may take some time.

Chairman Salmon: Mr. Williamson, do you have any views on how best to implement standardization?

Mr. Williamson: With the number of railroads in the United States or in the world that are using AREA designs, I think we must take a practical look at this thing. To get all railroads to change to standard designs concurrently is going to pose quite a problem.

I think the way to implement design standardization is geographicaly or regionally. As Mr. Woolford mentioned a little while ago, we have made some headway, though not as much as we might wish. I think in the West and in the Missouri Valley, the railroads have pretty well standardized on trackwork. I think if we can get various designs adopted regionally, then maybe we can take the best of each region and make a further expansion of standardization.

I think there is another advantage in regional standardization, which is that most manufacturers supply on a regional basis and they can stock, tool up and manufacture for that region.

I think this is the way we will have to approach it, and I think it is the way it will ultimately come.

Chairman Salmon: I hope, Mr. President, that the membership during this discussion has formulated questions in their minds which we have not answered. I should like at this time to permit, as far as the panel is able to answer, questions from you or the floor.

President Burris: Are there any questions from the floor? This is a pretty lively discussion, and you ought to have some. I know I do.

Mr. Code: Mr. Chairman, I should like to throw one more thing into the pot. There is another deterrent to general adoption of a particular standard that I think may have been overlooked in this discussion. That is, that regardless of what standard you adopt, you still have to live with your old standards. On our railroad there are standards for 100-lb switches and 130-lb switches and old standards for 85-lb switches. We have not been buying 85-lb switches for 40 years, but we still have them in track. We still have to live with those standards, at least for the 100- and 130-lb material, as we have to buy replacements for them.

When we adopt an AREA standard, you might say we are just adding another standard. We cannot do away with the old one. We have to live with it. In the case of the 115-lb material, it was relatively easy, because we were at the same time adopting a rail section we had not used before; consequently, there was no possibility of confusing an old standard with the new standard 115-lb material.

We are also trying to work around to the adoption of some of the AREA standards in some of the 140-lb material. In this weight, we have hundreds of turnouts in stock now to our present standards. If we adopt another present standard for 140 lb turnouts, we might have an element of confusion which could create some difficulty and expense.

President Burris: Does anyone else have any remarks? A thought came to me when Mr. Woolford was talking. He said he was assured by someone who made special trackwork that standardization could result in a cost reduction in the neghborhood of

25 percent. However, he said, this was not something he got from a man who prices the object.

Does this man mean that the 25 percent reduction in cost would go to the manufacturer and the railroads would not benefit?

Mr. Woolford: No, Mr. Burris. I did not intend that. I was trying to sound out from this individual as to what he thought the saving would be in the shop. I know that the accounting people do not always agree with the shop people's figures.

I wanted to get something real from the man who make the assemblies about what he considered his saving would be in being able to stockpile them and have them available. On that basis he assured me that there was a savings in the realm of 25 percent available to the railroads in the production of this material.

President Burris: Does anyone else have any questions of these gentlemen?

Standardization is something that we ought to have before us at all times. As Mr. Code has said, you have to live with what you have. Standardization can be something that binds you, and yet you should not be bound.

I am thinking of a quotation that Boss Kettering of General Motors made sometime ago. It went something like this:

"If it works, it's obsolete."

Now, many of the things that we do and that we make and that we maintain we might take that kind of look at.

Are there any other remarks? Mr. Magee?

G. M. Magee [AAR]: It seems to me it is pretty difficult to get standardization unless there is some incentive or something that will be gained by the railroads.

We ran into this on tie plates, for example. As I remember it, a standard punching and a limited number of sections were adopted for tie plates. Those were offered by the mills at a base price. The mills said, however, "We'll give you anything else you want, but there is a certain extra involved."

Twenty-five percent, the figure Mr. Woolford mentioned, is a pretty substantial saving in the price of frog and switch material. It seems to me that in order to get something actually accomplished, the frog and switch companies could select for study perhaps two or maybe even three of the rail sections that are more generally used, and also two or three of the frog and switch designs that are used. If they find they actually can accomplish savings by stockpiling this material and getting a better utilization of their work force and reducing engineering, it would seem to me they could price these particular items on the basis of their savings in construction cost. Then, the other items could be considered specialties and be sold at the same price as they are today.

This would give the railroads some incentive to adopt standard designs and turnouts.

I can understand that the railroads might not like this proposition too well, and it may put the manufacturers on the spot a little. Nevertheless, the proposition seems fair to me. It is about the only way I can see of getting standardized frog and switch material, because I see absolutely no reason why a railroad should standardize unless there is going to be some benefit to them to do so.

President Burris: Thank you, Mr. Magee.

Are there any other remarks?

W. Muller [American Brake Shoe Company]: In relation to Mr. Woolford's statement about a reduction in cost of 25 percent: Having studied this question quite a bit, I am unable to reconcile that kind of savings, especially since we have to maintain the old standards as well as the new ones. We do not save on material. We do not save on labor.

Mr. Woolford: Mr. Muller, I think you will save from being able to stockpile. In adopting standards there is no requirement that you make and stockpile frogs or switches to old standards. We are talking about the standards that would be adopted and agreed to—AREA standards. Those would be the only ones we would expect you to use to maintain a stockpile from which we would draw.

Your company assured us that a reduction could be made when the western railroads started discussing standardization.

Mr. Muller: Nothing like 25 percent.

Mr. Woolford: No. It was not 25 percent. But you gave us an off-the-cuff figure when we first entered into this study of standardization on the western railroads.

Mr. Muller: Our figure was, I think, something like a 5 percent reduction.

Mr. Woolford: No. It was 6 percent. (Laughter)

Mr. Muller: You only accrue savings through improvement in manufacture. We would not reduce our inventory of materials. Our labor would be the same. When we have periods of high production, such as now, there would be no chance to stock material. We are just able to keep up with production to meet the railroad requirements. Our men already are fully employed.

Mr. Woolford: That is not what I understand, that your men are always fully employed. During certain times of the year you have had reduction in forces. You have had to close down a few of your frog and switch shops because of limited purchases. Being able to work 12 months out of the year and stockpiling the materials should produce some saving.

Mr. Muller: We have been operating at full capacity for 18 months. I agree that conditions do cycle, but that has not been the case in the past 18 months.

The reason for my raising the question is that I did not want you gentlemen here all believing that you are going to get a 25 percent reduction. (Laughter)

Mr. Woolford: I had this assurance. It was not drawn out of the sky.

Mr. Code: It seems to me that possibly the real saving is not in adopting a new standard for everybody, but in getting rid of old standards. The more old standards you can throw out, the fewer patterns and castings and so on that the manufacturers have to keep around.

We have done something along that line, we have abandoned the 155-lb material. We do not buy it anymore. We have a lot of turnouts in the 155-lb class, but as they come up for renewal, we are changing to 140-lb material. The same applies to the old 130-lb section, which we do not buy anymore. We have any number of 130-lb turnouts, but when we reach the point where we have to renew them and cannot find second-hand material to do it, we change to one of the standard sections.

Chairman Salmon: I think that has been true with respect to the 112-lb section. Those railroads that had it have had to change their turnouts to 115-lb. They probably did not want to, but it was necessary. I think that sort of thing has helped.

C. E. Morgan [Milwaukee Road]: We operate a switch and frog shop, and it is not very hard for me to understand what Mr. Woolford is talking about. Any of you who have had to set up for a lot of individual parts know what the ratio of setting-up time is to production time on switch points and frog members and various other pieces that have to be machined.

Going back to the slow process that we hear mentioned once in awhile in arriving at standardization of track plans, I just want to bring out one thing. We have two different thicknesses ($1\frac{5}{32}$ in and $1\frac{3}{8}$ in) of flanges on wheels that move through turnouts, which adds to the complication in standardizing our clearances between gauge line and guardrail faces, running surface and the guardrail side of self-guarded frogs. The back of our wheels does not get anywhere near the wear, of course, that the flange side gets. We are working on this variable limit problem, trying to come up with a constant clearance as a standard. Progress has been made in it, and I think we will undoubtedly come up with something that will meet everybody's requirements. I hope we can see it in the near future.

CHAIRMAN SALMON: Thank you.

PRESIDENT BURRIS: Anyone else with a comment or a question?

D. H. SHOEMAKER (Northern Pacific Railway): I do not wish to disagree with Mr. Woolford, but we just finished a study of a proposed merger. We set up a committee of three purchasing agents, which interviewed practically all the manufacturers, not just the frog and switch manufacturers, on standards. We were attempting to develop some savings in this merger.

We found that we could not put one nickel in our pockets as a result of standardization. There was no savings in it for us.

I am for standardization. It happens that the Northern Pacific and the Great Northern and the Burlington are not standardized now, because we use No. 7 and No. 9 turnouts. You adopted a standard that doesn't fit us.

Mr. Barlow, Mr. Hall and Mr. Cruse spent months trying to come up with a standardization plan for the merged system to go into effect when we get our merger approved, if we ever do. We are not going to be standard with AREA. However, we do not expect that we are going to lose any money on our purchasing as a result.

In other words, do not get the idea that you are going to save much money with standardization. When we go to American Brake Shoe or Pettibone Mulliken, I want to see the proposals. There is no rhyme or reason for some of their prices. It all depends on how badly they want the business. (Laughter)

PRESIDENT BURRIS: Does anyone else wish to say something on this subject?

MR. MAGEE: I would just like to perhaps get in the last word. In this age of mass production, and fully realizing what it costs today per pound for frog and switch material, it is hard for me to believe that we could not save 25 percent on the cost of the frog and switch material if manufacturers were fully tooled up for standard items on a mass-production basis.

W. P. JONES [Louisville & Nashville]: We have been talking about the benefits of standardization from the standpoint of the user. Do we have anything on this from the standpoint of the manufacturer? When are they going to standardize?

PRESIDENT BURRIS: Would anybody care to answer that question, any representative of a manufacturer?

O. F. MAGNUS (American Brake Shoe Company): Actually there really is no standard as far as trackwork is concerned; there are too many variations. However, I can see Mr. Woolford's point of view and Mr. Williamson's and everybody else's.

As I see it, pricing is not in the realm of the engineering department, but the prices our sales department establishes for the products we manufacture is right and proper. I think you can see that from the yearly or quarterly statements of the company involved, which show the profit made on each item. You could see that there is no really terrific amount of profit in this business.

I can also see some savings, perhaps, if you have a standard and if you give us orders for sufficient quantities to eliminate a lot of expensive set-up time, as Mr. Morgan said, and if you accept delivery of this material. If we have to stock it in our quarters, then we have to have storehouses, which adds to our costs.

Your savings would become apparent immediately, if you could give us orders for standard material and if all of the railroads would standardize, not just one or two.

In the audience I see someone who can illustrate this. The minute the 1962 plans were out, Mr. Meyers [vice president and chief engineer] of the Chicago & North Western Railway issued an order that they would use the 1962 standards, and they have, right along. Because the North Western is the only railroad that did, that I know of—there may be others—I do not think they have realized savings anything like 25 percent.

I do not think we could possibly obtain such savings under any circumstances.

Of course, I do not know who gave Mr. Woolford that 25 percent quote. Maybe the gentleman was thinking of a situation where railroads use No 15 turnouts where possibly No. 10's would do. Perhaps there would be a 25 percent saving in such cases.

As I travel through the country I see where the railroads are using No. 15 turnouts, or Nos. 16 and 14. It seems as though No. 15 that the committee picked out is not the popular standard. Perhaps the No. 16 should have been the one, or the No. 14. Anyway, as you go up in numbers, the cost of the turnout increases. When these standard plans were made up the frogs were lengthened. That increased the price of the turnouts. There were other things put in the new plans that increased the price of the frog.

I can appreciate Mr. Magee's point of view, too. I think he has given us some food for thought. He mentioned that possibly the manufacturers should set up a standard. We have, in a measure. If you think back, you will remember that in the 1950's we made up what we called a Southwest Standard, which I think was the forerunner of the Western Standard Mr. Woolford has referred to. We manufactured to that standard. It was, generally speaking, a heavier standard than would be used throughout the country. It was a good standard, though.

I do not know whether any of the users actually realized any savings from this standard, except, perhaps, that resulting from the longer life of the heavier material.

In any event, that standard was for a No. 10 turnout, and I think it ceased to be a standard because a railroad would come to us and say, "Look, you make a standard No. 10, but we don't use No. 10, we use No. 11." Well, it was almost impossible to pass up the business, so we made the No. 11.

So I have to disagree with Mr. Magee a little. I think the standard should start with the railroad.

Mr. Woolford: Mr. Burris, I think I will have to take after Mr. Magnus. I do not think he listened to what I said. When I talked about standardization, I did not mean one railroad or two railroads. I said all the railroads. When we went to standardization on the western railroads, only three roads were involved. We never expected price reductions then. We merely were trying to start standardization so that the others would adopt it and eventually we could have standardization throughout the whole country.

J. P. Kleinkort (American Brake Shoe Company): Mr. Chairman, I purposely waited until late in this meeting to speak, because I already have said quite a bit about standardization on railroads in past years.

I am a little disappointed at the progress that has been made in that direction. I do think that the railroads are the ones that have to take the action.

We are in a too highly specialized field to start the action. I think it is very important that each railroad study how it can make use of the 1962 AREA plans. I doubt that much has been done along that line.

Price savings and standardization are matters that you are going to have to go after. I have previously said that this is not a one-year or two-year program; it is a program you will have to work on for 10 to 20 years to get the kind of standardization that will give you maximum savings. Therefore, you have work to do.

You do not need to worry about the pricing as far as the manufacturer is concerned. So long as you can place business you are going to get the best competitive price that product will take.

CHAIRMAN SALMON: Gentlemen, I do not believe the standardization problem is insurmountable. I hope you will agree that while much is yet to be done, a lot has been accomplished already.

The adoption of one standard gage by the American railroads—on one property, as I recall the accounts, the changeover was accomplished in one day—was one of the greatest steps toward standardization. Many construction and maintenance items are standard—rail, ties, ballast, joint bars, bolts, spikes, anchors and track tools, just to name a few.

Let us not become disheartened. The automobile industry, through its engineering committees, was and is the leaders in standards. Think of what their problems are. Their spring washers, for example, range in size by $\frac{1}{16}$-in increments from 6 naught to 1½ in and up to 2 in. They are made of at least four different alloys; in light, medium, heavy and extra-heavy steel gages; are anodized and oxidized; and are chrome, nickel or zinc plated. For this one item there are 4,000 different standards.

To me standardization is reducing any item to the least denominator.

Mr. President, that concludes the presentation of the special panel; also Committee 5's report. It has been a distinct pleasure to have had a part in this panel discussion, gentlemen, and I want to extend to you my sincere thanks.

PRESIDENT BURRIS: Thank you, Mr. Salmon, and our thanks to the members of your committee. I think this has been one of the most interesting discussions of this Convention, and I want to extend special thanks to the members of the panel.

Mr. Salmon, you and the members of your committee are now excused with the thanks of the Association. (Applause)

PRESIDENT BURRIS: Gentlemen, we have now completed our committee reports for this Convention.

You may be interested in the registration figures I have before me. They are:

Railroad men	1418
Non-railroad men	1039
Total registration	2457

Gentlemen, this is the best attended convention we have ever had. The biggest previous convention was in 1955, when there were 80 fewer people registered than at this one.

This is remarkable, I think, especially when you consider that ten years ago there were more engineers working on the railroads than now. I think in the past ten years roughly one-third of the men employed in that capacity are no longer so employed. This registration, therefore, is to me even more significant than it appears on the surface.

Closing Business Session

President Burris: I now convene the Closing Business Session of our Convention, which will include the installation of the new officers for the ensuing year.

I would like first to take this opportunity to thank all those people who have contributed to the work of our Association and to the success of this Convention. They have given most generously of their time and labor.

One of the groups I particularly would like to mention at this time is the Committee on Convention Arrangements under the direction of Ed Hastings, who has done an outstanding job.

The people with the hotels where we have our meetings, and here at McCormick Place, always hold up the planning of our Association as an ideal for other groups to emulate. Our Association possesses a reputation of knowing what we want and how to get it, and I believe a great deal of that is due to the work of our Arrangement Committees.

I would be remiss if I did not mention our retired secretary, Neal Howard, and his lovely and charming wife. Mr. Howard was with me during the first half of my administration. He consented to remain for a month or so as a consultant to make the transition to his successor a smoother one. He has done a wonderful job and he has been a great help to me.

We are indeed fortunate to have as his replacement a most capable man, Earl Hodgkins. I join Mrs. Burris in thanking all those women, who, with Mrs. Hodgkins, gave so generously of their time and energy in assisting with the social functions for the ladies.

I have just about run out of people to thank and things for which I can show my appreciation. I now ask, therefore, if there is any other business to come before this meeting.

L. A. Loggins (Southern Pacific Company, Past President, AREA): Mr. President, members and guests, I am sure I have the most pleasant assignment of the entire Convention, that of expressing the sincere thanks and appreciation of this Association to our outgoing President, Fred Burris.

Knowing that committee work is the heart of this Association, he has traveled far and near during the past year. He has attended many committee meetings. He has concentrated on committee contacts and the upgrading of committee activities.

Fred has represented the AREA well and ably at many outside meetings and functions, some of them in foreign countries.

We have a beautiful bronze plaque to present to you, Fred, from the Association, in recognition of your accomplishments and as a constant reminder of your successful and fruitful year as president of the AREA.

On that plaque is inscribed:

"THE AMERICAN RAILWAY ENGINEERING
ASSOCIATION
RECORDS ITS GRATEFUL APPRECIATION
TO
THOMAS FRED BURRIS
FOR HIS ABLE ADMINISTRATION OF THE
AFFAIRS OF THE ASSOCIATION DURING
HIS TERM AS PRESIDENT
1964 — 1965"

It is now my pleasure to welcome you into the ranks of the past presidents. As such, you will remain on the Board for two more years. During that two years your wise counsel and advice will be invaluable to the incoming young officers and directors of the Association.

We are also mindful of the constant support and assistance of Mrs. Burris, which contributed so much to the success of your administration as president.

Thanks, Fred and Kay, for a job well done. We wish you happiness and success in your future undertakings. (Applause)

President Burris: Thank you, Mr. Loggins.

I joined the AREA some 33 years ago, during the heart of the Depression. Our railroad did not at that time and does not now pay our membership fees. I joined as a young engineer, because I thought AREA would make it possible for me to do a better job for my railroad and that I in turn could make a better living.

I have encouraged young engineers to become members, and I hope you gentlemen will do the same for your young engineers.

The close of our Annual Convention each year brings with it not only a feeling of satisfaction but also some regrets, because it brings to an end the services of several members of our Board of Direction. I want to thank each member of the Board for his counsel, advice and support, particularly those members who, having completed their term of office, are retiring from the Board.

The closing of this meeting completes the service on the Board of Past President C. J. Code, assistant chief engineer of the Pennsylvania Railroad, who will, I understand, retire from railroad service very shortly. Realizing the great asset that Charley has been to this Association, the Board of Direction at its last meeting voted to raise his status to that of Honorary Member of the AREA.

Mr. Code, I think everybody saw you while you were up here during the panel discussion, so I am not going to ask you to stand again.

Other members of the Board of Direction completing their terms of office as director are: W. L. Young, resident vice president, Norfolk & Western Railway, Norfolk, Va.

T. B. Hutcheson, chief engineer, Seaboard Air Line Railroad, Richmond, Va.

C. E. Defendorf, chief engineer, New York Central System, New York City.

John Ayer, Jr., vice president-operations, Denver & Rio Grande Western Railroad, Denver, Colo.

These men have served our Association well in their official capacity on the Board. I want to express my deep appreciation to each of them.

It is now my privilege and pleasure to present the new directors and officers you have elected for the ensuing year. As I read your name, please come to the speaker's table and take a place at my right:

D. H. Shoemaker, chief engineer, Northern Pacific Railway, St. Paul, Minn.

M. S. Reid, assistant chief engineer—maintenance, Chicago & North Western Railway, Chicago.

J. B. Clark, chief engineer, Louisville & Nashville Railroad, Louisville, Ky.

J. A. Rust, chief engineer, Southern Railway System, Atlanta, Ga.

Gentlemen, I welcome you as directors of the Association. It is an office of high honor and responsibility you are assuming. I know you will enjoy your service on the Board of Direction and will bring much of value to its deliberations. Congratulations, you may be seated.

Our new president is A. V. Johnston, chief engineer, Canadian National Railways. [President-Elect Johnston was escorted to the platform by Past Presidents R. H. Beeder and L. A. Loggins.]

Our new senior vice president is J. M. Trissal, vice president, Illinois Central Railroad; who automatically advances to this position from that of Junior Vice President.

Your newly elected junior vice president is T. B. Hutcheson, chief engineer, Seaboard Air Line Railroad, and one of our retiring directors.

Mr. Johnston, I congratulate you upon your election to the highest position of honor in this Association, and I now proclaim you president. I know you are going to be greatly assisted this coming year by Mrs. Johnston. It is with pleasure and satisfaction that I turn over the responsibility of president to you. In doing so I want to place upon your lapel this pin, which is a replica of our emblem and which bears these words engraved on the back:

A. V. JOHNSTON
President
1965–1966

[Mr. Johnston assumed the office of president of AREA and presided over the meeting]

President Johnston: Thank you, Mr. Burris, for this emblem of our Association which you have presented to me. I am going to wear it with pride on all occasions. I am particularly happy to have you present it to me, because we have had a close, personal and friendly association since we first came on the Board, not quite at the same time, but we did serve together. Then, in the past two years, as I have been working with the Association as vice president and you have been advancing to the position you have just relinquished, our association has grown closer.

But now is the moment of truth. I no longer can use Fred as an example of how things are done in this Association. I am on my own from now on.

I wish to say I am sincerely aware of the honor which has been accorded to me with my election to the office of president of our Association. This is particularly true because, as perhaps all of you know, I am a Canadian, one of your neighbors to the north. I must say, however, that in my experience with AREA I found that the border between our two countries has been practically non-existent. It exists perhaps for the benefit of customs inspectors and immigration officials, but as far as AREA is concerned, I forget it most of the time.

I would like to be able to say I am the first Canadian to assume this office, but I cannot. There have been a number of others before me.

I accept this, the highest office in this very distinguished Association, with a sense of responsibility and humility. I follow a very distinguished group of predecessors in this office, each of whom felt, I am sure, the responsibility and obligation I feel now to advance the welfare and prestige of our Association.

If I ever had doubts about my ability to serve in this capacity, I lose many of them as I look around me and see those members of the Board who are present; those who are not here come to mind. I am relieved by the thought of the able and competent officers and staff members who are going to support me throughout the coming year.

I wish to mention particularly my two outstanding vice presidents, Mr. Trissal and Mr. Hutcheson, upon whom I am going to rely a great deal. I am sorry Charley Code is leaving us, but with every gain there if a loss, which one must accept.

Mention also must be made of the work that is being done by the chairmen, subcommittee chairmen and members of the various committees, all of whom are contributing a great deal to the success and advancement of our Association.

There is, too, of course, the wise counsel of those past presidents who have moved from the Board but who are in the background and are always available to offer assistance when it is needed, I am sure. I see Frank Woolford, for one, down there.

Then, too, there are the people, let us say, who really do the work—the staff at 59 East Van Buren Street. I have reference, for one, to our very able and competent new executive secretary, who is rapidly getting his feet under the table. From what I have seen, it will not be long before he will have full and complete control.

He cannot do it alone, anymore than I can. He is backed up very ably.

Beyond that, of course, there is Mr. Magee and his staff at the AAR Research Department. They do a lot of our technical work, and I am going to look to them for a great deal of help, especially Mr. Magee.

I look forward to a year of new achievement and innovation for the Association, a year which will see, I hope, a substantial increase in the membership—of the right kind. We want to encourage those members who are going to join us to be an asset to the Association, to come in with the idea that they are going to participate in committee work and in that way to advance our Association in all aspects.

One of the things we are going to do this year—and I will admit right now it is not going to make a big difference to the membership as far as 1965 is concerned—is to hold a regional meeting. Mr. Hodgkins outlined in his report our plans in this regard, so I will not go into detail.

We who have been working on this idea feel that over the long run it is going to do a great deal to encourage an increase in membership.

Before leaving the subject of our general well being, I wish to make reference, though Mr. Burris has already done so, to the ladies who are present and to the part they play in our Annual Meetings as well as throughout the rest of the year. They provide an important and very attractive backdrop at our Annual Meetings and I am sure they help to increase our attendance. I thank you very much.

W. E. Griffiths (Canadian National Railways): Mr. President, may I have the privilege of the floor?

President Johnston: Mr. Griffiths, you have the floor.

Mr. Griffiths: President Johnston, your associates on the Canadian National and more particularly your associates in the engineering organization of that railway, are justifiably proud of the honor and distinction which has been accorded to you in your election to the presidency of the American Railway Engineering Association.

On behalf of those associates, it is indeed a privilege to present you this gavel, to serve as a symbol of the great prestige and authority that goes with your appointment and also as a memento of this occasion.

I have linked this gavel to the present and the future. It also has connotations of the past, pertaining to your career on the railroad.

When the question of the gavel came up, we were asked to see if we could find something that had a link with your past. We came upon this piece of wood, part of an oak pile, driven as part of the reconstruction or rebuilding work in the ferry slips at Windsor, which I believe was the first job on the Canadian National that was carried out under your supervision.

There is the further small link, if you wish, in that the slips at Windsor are connected by ferry with those across the water at Detroit. So this tends to tie the two countries together.

I present this to you, Mr. President. (Applause)

President Johnston: Thank you, Mr. Griffiths, for the presentation of this gavel. You will notice, gentlemen, that we just had a bit of a discussion. I was trying to clarify something. I wasn't sure whether this gavel came from an oak pile that I assisted in the driving of the first day I started to work or if it was the first day I started in a supervisory position. I was informed that it was the supervisory job.

I would not be entirely truthful were I to say this presentation was entirely unexpected. As you know, I have been at a number of closing sessions, and this has happened before. However, I do sincerely appreciate it. I particularly appreciate it because it represents something from my early days, and also because it is a memento presented on behalf of all of my good friends on the Canadian National Railways, a token of good wishes for my year in AREA.

I am looking forward to using this gavel with pride and vigor at those meetings over which I will have the opportunity to preside from this point until March of 1966.

Before we adjourn, I would like to remind all members of the Board of Direction, including the retiring members and the newly elected members who are here, as well as all the members of the Committee on Convention Arrangements, that we will have a joint luncheon in Conference Room B immediately following the adjournment of the meeting. This will be followed by the post-convention meeting of the Board of Direction in Conference Room C.

Before closing the Annual Convention, may I ask if there is any further business to come before this meeting? If not, I shall use this beautiful gavel to close the meeting and declare the Sixty-Fourth Annual Convention of the American Railway Engineering Association and the concurrent Annual Meeting of the Engineering Division of AAR adjourned. (Applause)

[The meeting adjourned sine die at 12:10 pm]

Advance Report of Committee 3—Ties and Wood Preservation

Report on Assignment 5

Service Records

W. F. Arksey (chairman, subcommittee), A. B. Baker, C. M. Burpee, K. C. Edscorn, M. S. Edwards, F. J. Fudge, W. E. Fuhr, H. M. Harlow, R. P. Hughes, C. A. Peebles, R. B. Radkey, J. T. Slocomb, E. F. Snyder, L. S. Strohl, J. L. Williams.

Tie Renewals and Cost Per Mile of Maintained Track

The annual statistics compiled by the Bureau of Railway Economics, AAR, providing information on cross tie renewals and cost data for 1964 are presented herewith in Tables A and B.

The 1964 statistics compared with those for 1963 are as follows:

Year	*Total New Wooden Tie Renewals*	*Renewals Per Mile*
1963	* 12,558,194	41
1964	+ 13,563,840	44
5-Year Average, 1960 to 1964, incl.		41

---

* Includes 399 concrete ties.

+ Includes 294 concrete ties.

The average cost in 1963 was $3.87 and in 1964, $3.93. As noted on the tables these figures represent storekeepers average cost of ties charged out; they are not the actual cost or prices paid for the ties purchased during the period.

The percentage of new wood cross tie renewals has increased appreciably and now equals that of 1960 after three years at a lower rate. As for the past several years, the number of secondhand ties used in replacement, approximately 9 percent, affects the statistics.

Region an
NEW ENGLAND REGIO
Bangor & Aroosto
Boston & Maine
Canadian Pacific
Central Vermont
Maine Central
New York Connect
New York,New Hav
Total
GREAT LAKES REGIO
Ann Arbor
Delaware & Hudso
Detroit & Toledo
Erie-Lackawanna
Grand Trunk West
Lehigh & Hudson
Lehigh Valley
Monongahela
New York Central
New York,Susqueh
Pittsburgh & Lak
Total
CENTRAL EASTERN R
Akron,Canton & Y
Baltimore & Ohio
Bessemer & Lake
Central R.R.of N
Chicago & Easter
Chicago & Illino
Detroit,Toledo &
Elgin,Joliet & E
Illinois Termina
Long Island
Missouri-Illinoi
Monon
Pennsylvania
Penna.-Reading S
Reading Company
Staten Island Ra
Western Maryland
Total
POCAHONTAS REGION
Chesapeake & Ohi
Norfolk & Wester
Richmond,Fred'bu
Total
SOUTHERN REGION:
Alabama Great S
Atlanta & St.An
Atlanta & West
Atlantic Coast
Carolina & Nort
Central of Geor
Cincinnati,New
Clinchfield
Florida East Co
Georgia
Georgia & Flori
Georgia Souther
Gulf,Mobile & O
Illinois Centra
Louisville & Na
New Orleans & N
Norfolk Souther
Piedmont & Nort
Savannah & Atla
Seaboard Air Li
Southern
Tennessee Centr
Western Ry. of
Tota

Table A

CROSS TIE STATISTICS (EXCLUDING SWITCH & BRIDGE [illegible]) FOR CLASS I RAILROADS IN THE UNITED STATES [illegible] RAILROADS

Calendar year ended December 31, 19[illegible]

Region and road	Wooden cross ties laid in replacement			Track maintained by reporting railroad			Equated gross ton miles (thousands)		New wooden cross tie replacement averages			
	New ties: Number 1	New ties: Average cost 2	Second hand ties 3	Total miles 4	Total cross ties 5	Cross ties per mile 6	Total 7	Per mile of track 8	Per cent renewal to all ties 9	Number laid per mile 10	Renewal cost per mile 11	Cost per 1,000 g.t.m. 12
NEW ENGLAND REGION												
Bangor & Aroostook	[illegible]	$3.91	-	760.6[illegible]	[illegible]	2 878	1 674 5[illegible]	[illegible]	[illegible]	96	$377	17.12¢
Boston & Maine	14 9[illegible]	[illegible]	-	[illegible]	[illegible]	2 950	8 209 277	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Canadian Pacific (lines in Me.)	[illegible]	[illegible]	-	211.04	[illegible]	2 925	1 512 439	[illegible]	[illegible]	113	408	[illegible]
Central Vermont	20 [illegible]	[illegible]	98	[illegible]	[illegible]	[illegible]	[illegible]	3 641	1.69	[illegible]	[illegible]	[illegible]
Maine Central	[illegible]	[illegible]	-	1 084.31	3 244 247	[illegible]	[illegible]	2 369	2.03	61	[illegible]	[illegible]
New York Connecting	[illegible]	[illegible]	-	26.30	82 375	[illegible]	[illegible]	[illegible]	[illegible]	23	127	.50
New York, New Haven & Hartford	84 465	[illegible]	-	3 152.70	9 987 753	[illegible]	[illegible]	4 706	[illegible]	27	[illegible]	[illegible]
Total	[illegible]	3.89	98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	140	3.61
GREAT LAKES REGION												
Ann Arbor	13 742	4.71	7[illegible]	394.15	1 199 004	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Delaware & Hudson	10 1[illegible]	4.12		1 122.99	[illegible]	3 073	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Detroit & Toledo Shore Line	[illegible]	5.39	[illegible]	155.66	450 498	2 894	644 50[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Erie-Lackawanna	5 702	[illegible]	-	[illegible]	[illegible]	2 960	44 568 195	[illegible]	[illegible]	1	[illegible]	[illegible]
Grand Trunk Western	67 878	[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	5 640	1.18	7	[illegible]	[illegible]
Lehigh & Hudson River	[illegible]	[illegible]	-	[illegible]	282 880	2 766	[illegible]	[illegible]	1.08	30	72	.74
Lehigh Valley	[illegible]	3.62	-	2 107.83	[illegible]	3 026	[illegible]	[illegible]	.15	5	16	[illegible]
Monongahela	[illegible]	4.76	-	[illegible]	[illegible]	3 017	761 845	[illegible]	.08	2	[illegible]	[illegible]
New York Central	262 693	[illegible]	398 954	16 478.71	50 612 102	3 071	114 651 162	6 958	.52	16	[illegible]	[illegible]
New York, Susquehanna & Western	[illegible]	4.83	4 614	[illegible]	422 278	[illegible]	[illegible]	648	1.17	34	165	[illegible]
Pittsburgh & Lake Erie	[illegible]	4.35	14 531	[illegible]	[illegible]	[illegible]	[illegible]	4 264	[illegible]	10	[illegible]	[illegible]
Total	393 693	[illegible]	418 080	[illegible]	[illegible]	3 048	191 458 740	6 635	.45	14	65	[illegible]
CENTRAL EASTERN REGION												
Akron, Canton & Youngstown	[illegible]	[illegible]	35 140	[illegible]	[illegible]	2 950	426 685	[illegible]	.02	1	[illegible]	[illegible]
Baltimore & Ohio	451 041	3.98	-	9 181.35	[illegible]	[illegible]	75 597 125	[illegible]	[illegible]	49	196	[illegible]
Bessemer & Lake Erie	15 668	[illegible]		[illegible]	1 158 510	3 000	3 235 379	8 378	1.35	41	166	1.98
Central R. R. of New Jersey	8 480	[illegible]		[illegible]	[illegible]	2 798	5 539 098	4 883	[illegible]	7	16	[illegible]
Chicago & Eastern Illinois	70 546	4.13	-	1 249.12	[illegible]	3 043	[illegible]	[illegible]	1.86	56	[illegible]	[illegible]
Chicago & Illinois Midland	[illegible]	[illegible]	3 232	163.56	[illegible]	3 000	[illegible]	7 395	.23	7	[illegible]	[illegible]
Detroit, Toledo & Ironton	[illegible]	4.26	1 851	604.59	[illegible]	2 880	2 816 387	[illegible]	1.71	49	[illegible]	[illegible]
Elgin, Joliet & Eastern	49 565	3.91	-	828.88	[illegible]	[illegible]	[illegible]	2 590	1.95	60	234	[illegible]
Illinois Terminal	8 128	[illegible]	1 845	364.48	1 130 070	3 100	965 300	[illegible]	[illegible]	22	73	[illegible]
Long Island	[illegible]	[illegible]	-	692.11	1 992 482	[illegible]	[illegible]	[illegible]	1.19	[illegible]	115	[illegible]
Missouri-Illinois	[illegible]	[illegible]	-	205.95	644 761	3 131	876 508	4 256	.13	[illegible]	14	[illegible]
Monon	[illegible]	3.68	-	716.28	[illegible]	3 108	[illegible]	[illegible]	[illegible]	47	[illegible]	[illegible]
Pennsylvania	737 577	3.71	-	18 762.14	[illegible]	2 867	158 981 051	8 474	[illegible]	[illegible]	146	1.72
Penna.-Reading Seashore Lines	[illegible]	[illegible]	-	[illegible]	1 311 36[illegible]	2 683	635 890	1 301	1.08	29	115	[illegible]
Reading Company	[illegible]	[illegible]	-	[illegible]	6 883 419	2 836	13 472 131	5 550	2.00	57	[illegible]	[illegible]
Staten Island Rapid Transit	2 587	[illegible]	-	[illegible]	[illegible]	2 560	137 578	1 860	1.37	35	186	[illegible]
Western Maryland	59 162	4.52	-	[illegible]	3 322 425	2 913	8 300 286	7 278	1.78	[illegible]	235	3.22
Total	[illegible]	3.88	42 068	38 638.32	111 673 946	2 890	289 151 668	7 484	1.47	43	165	2.21
POCAHONTAS REGION												
Chesapeake & Ohio	361 923	4.09	-	8 176.45	[illegible]	3 000	76 956 577	9 412	1.48	44	181	[illegible]
Norfolk & Western	[illegible]	4.55	-	12 147.22	58 775 898	4 839	114 257 056	9 406	.80	39	175	1.86
Richmond, Fredericksburg & Potomac	18 124	4.71	227	[illegible]	[illegible]	3 241	4 541 697	11 174	1.38	45	210	1.88
Total	848 170	[illegible]	227	20 730.11	84 622 669	4 082	195 755 330	9 443	1.00	41	178	1.89
SOUTHERN REGION												
Alabama Great Southern	36 640	4.84	-	552.98	1 704 603	3 083	4 326 404	7 824	2.15	[illegible]	321	4.10
Atlanta & St.Andrews Bay	[illegible]	4.86	[illegible]	119.55	362 394	3 031	398 680	[illegible]	1.46	44	215	[illegible]
Atlanta & West Point	[illegible]	4.00	-	135.84	[illegible]	2 656	642 056	[illegible]	1.89	50	201	[illegible]
Atlantic Coast Line	[illegible]	c 3.89	-	[illegible]	22 311 511	3 110	45 531 744	6 347	1.98	61	239	[illegible]
Carolina & Northwestern	-	-	-	[illegible]	952 933	3 156	182 777	605	-	-	-	-
Central of Georgia	153 115	[illegible]	-	1 572.93	[illegible]	4 059	[illegible]	[illegible]	2.40	97	357	6.27
Cincinnati, New Orleans & T. P.	[illegible]	[illegible]	-	709.66	2 201 266	3 102	9 570 130	13 486	2.10	65	324	2.41
Clinchfield	14 798	[illegible]	-	432.95	1 404 832	[illegible]	6 012 916	[illegible]	1.05	34	142	[illegible]
Florida East Coast	[illegible]	[illegible]	25 781	[illegible]	[illegible]	2 999	3 865 168	3 286	1.20	36	164	4.98
Georgia	37 187	4.09		436.78	1 327 436	3 039	1 702 796	3 899	2.80	85	348	8.94
Georgia & Florida	1 843	[illegible]	-	368.46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]
Georgia Southern & Florida	2 616	4.85	-	474.56	1 491 882	3 144	2 024 509	4 266	.18	6	27	[illegible]
Gulf, Mobile & Ohio	149 560	[illegible]	[illegible]	3 417.59	[illegible]	3 168	[illegible]	5 041	1.38	44	157	3.12
Illinois Central	492 061	4.28	1 230	9 501.36	29 044 201	3 057	58 898 279	6 199	1.69	52	[illegible]	3.58
Louisville & Nashville	488 815	3.94	-	[illegible]	23 115 679	[illegible]	60 329 572	7 445	[illegible]	60	237	3.19
New Orleans & Northeastern	[illegible]	5.02		304.88	[illegible]	3 094	2 851 341	9 352	.58	18	91	.97
Norfolk Southern	52 714	3.27	-	709.00	[illegible]	[illegible]	1 627 567	2 296	2.55	74	[illegible]	10.59
Piedmont & Northern	15 451	4.96	-	210.00	647 430	3 083	399 294	1 901	2.39	[illegible]	365	19.19
Savannah & Atlanta	[illegible]	4.52	-	157.64	481 772	3 056	412 242	[illegible]	.08	2	11	[illegible]
Seaboard Air Line	d 419 521	d 3.97	-	5 667.98	17 079 252	3 013	40 528 637	7 150	2.46	74	294	4.11
Southern	667 760	4.95	-	8 248.74	25 780 456	3 125	54 376 069	6 592	2.59	81	401	6.08
Tennessee Central	31 686	3.17	-	343.95	1 041 481	3 028	504 844	1 468	3.04	92	292	19.87
Western Ry. of Alabama	9 193	4.14	-	179.30	[illegible]	2 988	783 387	4 369	1.72	51	212	4.85
Total	3 120 598	4.20	39 692	[illegible]	[illegible]	[illegible]	321 415 631	6 390	2.02	62	261	4.08

Region a
NORTHWESTERN REGI
Chicago & North
Chicago Great We
Chicago,Milw.,St
Duluth,Missabe &
Duluth,Winnipeg
Great Northern
Green Bay & West
Lake Superior &
Minneapolis,Nort
Northern Pacific
Soo Line R.R. Co
Spokane Internat
Spokane,Portland
Tota
CENTRAL WESTERN R
Atchison,Topeka
Chicago,Burlingt
Chicago,Rock Isl
Colorado & South
Colorado & Wyomi
Denver & Rio Gra
Fort Worth & Den
Northwestern Pac
Pacific Electric
San Diego & Ariz
Southern Pacific
Toledo,Peoria &
Union Pacific
Western Pacific
Tota
SOUTHWESTERN REG
Kansas City Sou
Kansas,Oklahoma
Louisiana & Ark
Missouri-Kansas-
Missouri Pacifi
Quanah,Acme & P
St.Louis-San Fr
St.Louis Southw
Texas & Pacific
Texas Mexican
Tot
Grand Total - U
CANADIAN ROADS:
Canadian Nation
Canadian Pacifi
Ontario Northla

T[illegible]

CROSS TIE STATISTICS (EXCLUDING SWITCH AND BRIDGE TIES) FOR CLASS I [illegible] IN THE UNITED STATES AND CLASS I CANADIAN RAILROADS

Calendar Year ended December 31, 1964

Region and Road	Wooden cross ties laid in replacement: New ties: Number	New ties: Average cost	Second hand ties	Track maintained by reporting railroad: Total miles	Total cross ties	Cross ties per mile	Equated gross ton-miles (thousands) [a]: Total	Per mile of track	New wooden cross tie replacement averages: Per cent renewals to all ties	Number laid per mile	Renewal cost per mile	Renewal cost per 1,000 GTM
	1	2	3	4	5	6	7	8	9	10	11	12
NORTHWESTERN REGION												
Chicago & North Western	[illegible] 421	$5.03	170 638	13 419.82	39 952 683	2 977	43 170 491	[illegible] 217	.48	29	[illegible] 47	4 58¢
Chicago Great Western	[illegible] 816	[illegible]		1 7[illegible] 42	5 341 025	3 006	7 678 [illegible]	4 321	1 38	42	[illegible]	[illegible]
Chicago, Milw., St Paul & Pac	[illegible]	4.15	70 721	13 033.62	39 619 674	3 040	49 646 815	3 804	.7	17	72	1 84
Duluth Missabe & Iron Range	[illegible]	2 16	-	886.73	2 641 587	2 979	3 720 686	4 196	1 34	40	87	2 07
Duluth, Winnipeg & Pacific	9 540	3 01	-	20[illegible]	568 257	2 852	1 329 801	[illegible] 448	1 [illegible]	[illegible]	[illegible]	[illegible] 16
Great Northern	[illegible] 167	4 67	17 479	[illegible] 975.73	30 947 917	3 102	54 298 269	5 443	1 81	56	262	4 81
Green Bay & Western	3 910	[illegible]	-	264.39	761 433	2 880	64[illegible] 884	[illegible]	[illegible]	15	[illegible]	2 16
Lake Superior & Ishpeming	[illegible]	[illegible]	-	238.89	716 670	3 00[illegible]	21[illegible] [illegible]51	917	[illegible]	25	-	8 5[illegible]
Minneapolis, Northfield & Sou.	5 433	4 04	-	86 0[illegible]	217 449	2 417	[illegible]	[illegible] 101	2 [illegible]1	[illegible]	-	6 21
Northern Pacific	[illegible]	3 [illegible]4	-	[illegible] [illegible]68 15	26 277 202	2 898	43 631 14[illegible]	4 811	1 81	[illegible]	1[illegible]	4 0[illegible]
Soo Line R R Co	[illegible] 118	[illegible]	22 35[illegible]	5 268.72	15 976 701	3 032	15 380 539	[illegible] 919	1 4[illegible]	43	16[illegible]	5 [illegible]
Spokane International	1 [illegible]1	4.13		176.14	517 043	2 935	393 787	[illegible]	.47	11	[illegible]	[illegible]
Spokane, Portland & Seattle	6[illegible] 14[illegible]	4 34	-	1 144.00	3 [illegible]28 050	3 084	7 136 942	6 241	1 87	58	2[illegible]1	[illegible]
Total	2 [illegible]	4.26	281 191	[illegible]	1[illegible] 191	3 008	227 [illegible]	4 049	1 [illegible]	38	1[illegible]	[illegible]
CENTRAL WESTERN REGION												
Atchison, Topeka & Santa Fe	822 223	3.51	-	19 544.38	62 658 585	3 206	173 223 092	8 86[illegible]	1 31	4[illegible]	148	1 67
Chicago, Burlington & Quincy	364 882	3.91	24 008	11 165.89	34 480 [illegible]69	3 088	63 936 645	5 726	1 06	33	128	[illegible]
Chicago, Rock Island & Pac.	438 413	3.21	-	9 626.12	28 685 700	2 980	50 061 246	[illegible] 201	1 [illegible]	46	141	[illegible]1
Colorado & Southern	[illegible] 036	3.85	1 1[illegible]2	768.99	2 266 982	2 948	3 878 892	[illegible]	1 [illegible]	59	225	4 [illegible]
Colorado & Wyoming	1 535	4.00		103.16	[illegible] 579	3 [illegible]	101 318	952	.46	15	[illegible]	[illegible]
Denver & Rio Grande Western	142 [illegible]	3 98	14 359	3 081.00	[illegible] 244	3 091	19 424 264	6 366	1 50	46	184	[illegible]
Fort Worth & Denver	34 261	3.25	6 181	1 254.00	3 769 180	3 006	4 993 338	1 482	91	27	83	2 [illegible]
Northwestern Pacific	1 547	4 90	28 183	419.59	1 198 264	2 856	1 829 130	4 359	13	4	14	3[illegible]
Pacific Electric	11 544	2.36	-	420.23	1 079 056	2 568	378 418	901	1 07	27	65	7 21
San Diego & Arizona Eastern	5 717	2.35	1 839	153.22	441 265	2 880	210 259	1 372	1 30	37	88	6 39
Southern Pacific Co	749 8[illegible]0	3 10	339 077	16 213.92	48 851 471	3 013	170 178 053	10 496	1 5[illegible]	46	143	1 37
Toledo, Peoria & Western	13 512	3.33	-	292.27	925 911	3 168	1 067 343	3 652	1 46	46	154	[illegible] 22
Union Pacific	516 884	4 17	-	13 250.81	37 452 707	2 826	134 188 642	10 504	1 38	39	161	1 [illegible]
Western Pacific	6[illegible] [illegible]81	5.90	-	1 545.15	4 612 485	2 985	13 796 479	8 929	1 46	44	257	2 88
Total	3 215 624	3.59	415 009	77 838.73	236 278 698	3 035	642 272 749	8 251	1.36	41	148	1 80
SOUTHWESTERN REGION												
Kansas City Southern	8[illegible] 690	3 11	-	1 372 4[illegible]	[illegible] 339 552	3 162	10 891 832	7 936	1 91	60	187	2 16
Kansas Oklahoma & Gulf	39 68[illegible]	4 03	-	224 41	68[illegible] 253	2 987	1 111 218	4 844	5 79	173	596	14 38
Louisiana & Arkansas	104 1[illegible]8	3.17	-	494 [illegible]0	2 914 288	3 258	5 290 886	5 315	3 58	117	370	6 26
Missouri-Kansas-Texas	4[illegible] 438	3.51	-	3 366.58	10 717 506	3 183	11 842 718	3 518	4 42	141	494	14 03
Missouri Pacific	66[illegible] [illegible]	3.46	-	11 232.60	34 629 651	3 083	70 448 581	6 272	1 93	60	206	3 29
Quanah, Acme & Pacific	1 634	4.13	-	144 75	458 568	3 168	476 737	3 2[illegible]4	.36	11	47	1 42
St Louis-San Francisco	355 904	3.12	-	5 900 05	18 552 028	3 144	30 581 363	5 183	1 92	60	188	6 61
St Louis Southwestern	140 363	3.59	1 040	1 747.18	5 343 012	3 058	19 740 188	11 298	2 63	90	289	2 [illegible]
Texas & Pacific	8[illegible] [illegible]	3.44	-	2 210.46	6 449 643	2 918	17 692 876	8 004	1 33	39	134	1 67
Texas Mexican	2[illegible] [illegible]	2 40	-	239 7[illegible]	759 433	3 168	291 917	1 218	2 68	85	204	16 [illegible]
Total	1 974 049	3.39	1 040	27 337.72	84 848 934	3 104	168 368 516	6 159	2 33	72	245	3 98
Grand Total - United States	13 563 840	3.93	1 197 405	307 143.22	951 008 425	3 096	2 066 665 146	6 724	1 43	44	174	2.58
CANADIAN ROADS												
Canadian National	1 [illegible]	[illegible]	-	29 104.	85 455 5[illegible]7	2 936	e	e	1.5	43	144	e
Canadian Pacific	1 111 709	3.12	-	20 673.60	60 987 465	2 950	96 983 530	4 691	1.93	54	168	3.58
Ontario Northland	45 350	4.30	-	666.9	1 985 587	2 977	2 222 784	3 333	2.28	68	292	8.7

a Gross ton-miles of cars and contents, plus two times gross ton-miles of locomotives and tenders in freight service, plus three times gross ton-miles of locomotives and tenders in passenger service

b Includes New York, Chicago & St Louis merged with Norfolk & Western and Pittsburgh & West Virginia and Wabash leased by Norfolk & Western effective October 16, 1964, for entire year.

c Includes 12 concrete ties at an average cost of $15 58 per tie

d Includes 282 concrete ties at an average cost of $12.21 per tie

e Not reported.

Cr Credit

Note "Average cost" as shown in Column 2 represents storekeepers average cost of ties charged out and used They are not the actual costs of prices paid for the ties purchased during the period

Association of American Railroads, Bureau of Railway Economics, Washington, D.C., from Annual Reports of Class I Railroads to the Interstate Commerce Commission

May 1965

NEW ENGLAND REG
Bangor & Aro
Boston & Mai
Canadian Pac
Central Verm
Maine Centra
New York Con
New York,New
T
GREAT LAKES RE
Ann Arbor
Delaware & H
Detroit & To
Erie-Lackawa
Grand Trunk
Lehigh & Hud
Lehigh Valle
Monongahela
New York Cen
New York,Sus
Pittsburgh &
CENTRAL EASTER
Akron,Canton
Baltimore &
Bessemer & L
Central R.R.
Chicago & Ea
Chicago & Il
Detroit,Tole
Elgin,Joliet
Illinois Ter
Long Island
Missouri-Ill
Monon
Pennsylvania
Penna.-Readi
Reading Comp
Staten Islan
Western Mary
POCAHONTAS REG
Chesapeake &
Norfolk & We
Richmond,Fre
SOUTHERN REGI
Alabama Gre
Atlanta & St
Atlanta & We
Atlantic Coa
Carolina &
Central of G
Cincinnati,
Clinchfield
Florida East
Georgia
Georgia & Fl
Georgia Sou
Gulf,Mobile
Illinois Ce
Louisville
New Orleans
Norfolk Sou
Piedmont &
Savannah &
Seaboard Ai
Southern Ry
Tennessee C
Western Ry.

NUMBER AND [illegible] COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED [illegible]

[illegible] roads in the United States and [illegible] Canadian roads, by year, and [illegible]

Note All figures are exclusive of bri[illegible]

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent of new wood cross tie renewals to all ties in track					
	1960	1961	1962	1963	1964	5 year average	1960	1961	1962	1963	1964	5 year average	1960	1961	1962	1963	1964	5 year average
NEW ENGLAND REGION																		
Bangor & Aroostook	126	106	100	94	96	104	$416	$391	$390	$374	$377	$390	[illegible]	[illegible]	3.47	-	3.35	[illegible]
Boston & Maine	3	-	3	1	7	4	10	18	11	11	26	15	[illegible]	.16	[illegible]	[illegible]	[illegible]	[illegible]
Canadian Pacific (lines in Me.)	71	74	20	100	113	76	277	274	61	360	408	276	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Central Vermont	110	60	95	79	49	79	446	209	336	338	226	311	3.71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maine Central	64	54	56	64	61	61	254	232	232	249	236	241	2.13	1.98	1.95	2.13	2.03	2.04
New York Connecting	42	48	43	62	23	54	526	261	248	339	127	300	2.92	1.54	[illegible]	[illegible]	[illegible]	[illegible]
New York, New Haven & Hartford	32	36	28	27	27	30	124	140	107	105	101	115	1.02	1.16	[illegible]	[illegible]	[illegible]	[illegible]
Total	41	38	35	37	36	37	153	145	135	144	140	143	1.34	1.26	1.17	1.22	1.18	1.23
GREAT LAKES REGION:																		
Ann Arbor	18	34	21	8	35	23	83	114	108	38	164	102	.54	[illegible]	.68	.25	[illegible]	[illegible]
Delaware & Hudson	46	-	-	1	3	11	131	2	1	6	37	35	1.49	.02	-	.05	[illegible]	.37
Detroit & Toledo Shore Line	25	10	29	7	59	26	140	53	168	33	318	142	.88	.33	1.01	.23	[illegible]	[illegible]
Erie-Lackawanna	20	-	1	-	1	4	70	-	3	2	5	16	.68	-	[illegible]	.02	.03	[illegible]
Grand Trunk Western	37	44	41	33	37	38	175	204	178	142	167	173	1.18	1.40	1.31	1.03	1.18	[illegible]
Lehigh & Hudson River	43	39	46	27	30	37	207	177	210	82	72	150	1.57	1.42	1.66	.98	1.08	1.34
Lehigh Valley	30	24	24	15	5	20	115	91	96	59	16	75	1.00	.80	.80	.50	.15	.65
Monongahela	23	35	36	17	-	23	112	153	153	76	11	101	.74	1.20	1.21	.58	.06	.77
New York Central	24	-	5	9	16	11	66	-	24	41	78	42	.73	-	.17	.29	.52	.34
New York, Susquehanna & Western	1	1	1	-	34	7	6	6	5	1	165	37	.04	.04	.05	.01	1.17	.26
Pittsburgh & Lake Erie	45	27	18	4	10	21	158	78	70	16	43	73	1.47	.88	.59	.12	[illegible]	.68
Total	26	9	11	12	14	14	91	40	53	56	65	61	.83	.30	.36	.41	.45	.47
CENTRAL EASTERN REGION																		
Akron, Canton & Youngstown	7	5	4	1	1	4	31	26	17	2	2	16	.25	.18	.13	.02	.02	[illegible]
Baltimore & Ohio	39	80	73	67	49	62	111	299	267	257	196	226	1.37	2.80	2.53	2.31	1.69	2.14
Bessemer & Lake Erie	41	38	43	35	41	40	193	183	205	162	166	182	1.22	1.14	1.42	1.18	1.35	1.26
Central R.R of New Jersey	14	21	30	25	7	19	62	96	129	72	16	75	.50	.74	1.07	.88	.27	.69
Chicago & Eastern Illinois	45	19	41	41	56	40	194	86	168	167	233	170	1.49	.64	1.34	1.34	1.86	1.33
Chicago & Illinois Midland	17	42	30	30	7	25	64	161	133	159	34	110	.57	1.40	1.01	.99	.23	.84
Detroit, Toledo & Ironton	25	33	29	38	49	35	110	140	111	148	210	144	.86	1.14	.99	1.30	1.71	1.20
Elgin, Joliet & Eastern	55	37	34	51	66	47	219	147	136	208	234	189	1.80	1.21	1.11	1.66	1.95	1.55
Illinois Terminal	6	26	5	2	22	12	20	76	17	10	73	39	.17	.83	.15	.08	.72	.39
Long Island	53	62	34	67	34	50	223	254	131	236	115	192	1.94	2.29	1.23	2.43	1.19	1.82
Missouri-Illinois	14	5	2	1	4	5	33	13	5	2	14	13	.44	.15	.05	.02	.13	.16
Monon	71	25	42	46	47	46	272	98	159	174	174	175	2.30	.81	1.35	1.49	1.52	1.49
Pennsylvania	38	27	38	31	39	35	153	110	165	127	146	140	1.34	.93	1.33	1.08	1.37	1.21
Penna.-Reading Seashore Lines	68	50	62	64	29	55	292	195	226	244	115	214	2.51	1.85	2.30	2.37	1.08	2.02
Reading Company	16	22	35	49	57	36	73	102	153	172	237	147	.58	.79	1.23	1.72	[illegible]	[illegible]
Staten Island Rapid Transit	10	90	24	24	35	35	44	294	73	88	186	137	.39	3.14	.96	.93	1.37	1.36
Western Maryland	53	47	52	51	52	51	236	207	229	228	235	227	1.83	1.60	1.78	1.77	1.78	1.75
Total	36	41	46	43	41	42	141	161	185	168	165	164	1.31	1.41	1.59	1.48	1.47	1.45
POCAHONTAS REGION:																		
Chesapeake & Ohio	25	18	25	31	44	29	101	77	104	123	181	118	.84	.61	.83	1.04	1.48	.96
Norfolk & Western a	30	24	24	29	39	29	131	104	113	135	175	132	.97	.76	.77	.93	.80	.85
Richmond, Fred'burg & Potomac	45	18	15	29	45	30	195	78	63	132	210	136	1.39	.55	.46	.90	1.38	.94
Total	28	20	25	31	41	29	115	84	113	131	178	124	.92	.65	.83	1.01	1.00	.88
SOUTHERN REGION																		
Alabama Great Southern	61	24	28	27	66	41	276	113	136	129	321	195	2.01	.80	.94	.88	2.15	1.36
Atlanta & St.Andrews Bay	68	53	78	35	44	56	335	251	370	160	215	266	2.25	1.75	2.59	1.16	1.46	1.84
Atlanta & West Point	86	8	71	52	50	53	345	26	272	224	201	214	3.18	.29	2.66	1.98	1.89	2.00
Atlantic Coast Line	70	68	69	70	61	68	267	252	266	264	239	258	2.24	2.17	2.23	2.25	1.98	2.17
Carolina & Northwestern	-	-	1	1	-	-	-	-	3	4	-	1	-	-	.02	.03	-	.01
Central of Georgia	65	108	134	96	97	100	213	398	475	325	357	354	2.26	3.74	4.65	3.31	2.40	3.27
Cincinnati, New Orleans & Tex.Pac.	47	68	75	33	65	58	215	319	348	160	324	273	1.68	2.29	2.52	1.11	2.10	1.94
Clinchfield	59	25	23	29	34	34	242	101	97	121	142	141	1.57	.67	.62	.88	1.05	.96
Florida East Coast	65	47	71	8	36	49	371	221	321	38	164	223	2.94	1.62	2.38	.28	1.20	1.68
Georgia	109	106	103	83	85	97	404	395	399	325	348	374	3.58	3.50	3.39	2.75	2.80	3.20
Georgia & Florida	265	172	106	-	5	110	858	547	201	-	24	326	9.80	6.39	3.94	-	.19	4.06
Georgia Southern & Florida	103	73	62	38	6	57	469	359	295	181	27	266	3.26	2.40	1.97	1.21	.18	1.80
Gulf, Mobile & Ohio	56	34	33	37	44	41	204	129	117	131	157	148	1.75	1.07	1.05	1.17	1.38	1.28
Illinois Central	42	39	57	48	52	48	168	163	244	200	222	199	1.36	1.26	1.89	1.59	1.69	1.56
Louisville & Nashville	60	17	36	66	60	48	211	54	128	249	237	176	2.11	.58	1.25	2.35	2.11	1.68
New Orleans & Northeastern	77	56	70	112	16	67	382	274	333	541	91	324	2.60	1.91	2.35	3.79	.58	2.25
Norfolk Southern	75	71	92	61	74	75	252	265	253	183	243	239	2.55	2.44	3.14	2.10	2.55	2.56
Piedmont & Northern	140	143	101	106	74	113	699	714	500	531	365	562	4.54	4.65	3.28	3.43	2.39	3.66
Savannah & Atlanta	123	164	248	109	2	129	503	642	771	491	11	484	3.98	5.31	8.11	3.57	.08	4.21
Seaboard Air Line	82	61	69	71	74	71	323	242	278	286	294	285	2.73	2.03	2.30	2.36	2.46	2.38
Southern Ry.	36	43	33	28	81	44	165	203	156	136	401	212	1.15	1.39	1.05	.88	2.59	1.41
Tennessee Central	61	93	97	93	92	87	182	273	284	304	292	267	2.02	3.06	3.20	3.09	3.04	2.88
Western Ry. of Alabama	100	84	82	56	51	75	409	339	302	245	212	301	3.36	2.80	2.74	1.87	1.72	2.50
Total	60	49	57	54	62	56	233	196	225	214	261	226	1.97	1.62	1.88	1.79	2.02	1.86

NORTHWESTERN
Chicago &
Chicago Gr
Chicago,Mi
Duluth,Mis
Duluth,Win
Great Nort
Green Bay
Lake Super
Minneapoli
Northern P
Soo Line
Spokane In
Spokane,Po
CENTRAL WEST
Atchison,T
Chicago,Bu
Chicago,Ro
Colorado &
Colorado &
Denver & R
Fort Worth
Northweste
Pacific El
San Diego
Southern P
Toledo,Peo
Union Paci
Western Pa
SOUTHWESTERN
Kansas Cit
Kansas,Okl
Louisiana
Missouri-
Missouri
Quanah,Ac
St.Louis-
St.Louis
Texas & P
Texas Mex
Grand Tot
CANADIAN RO
Canadian
Canadian
Ontario N

NUMBER AND AGGREGATE COST OF NEW WOOD CROSS TIE RENEWALS PER MILE OF MAINTAINED [illegible] RATIO OF NEW WOOD CROSS TIE RENEWALS [illegible] IN MAINTAINED [illegible]

Class I roads in the United States and large Canadian roads, [illegible] and for the average of five years 196[illegible] inclusive

Note All figures are exclusive of [illegible] and switch ties

Road	Number of new wood cross tie renewals per mile of maintained track						Aggregate cost of new wood cross tie renewals per mile of maintained track						Per cent new wood cross tie renewals to all ties in tracks					
	1960	1961	1962	1963	1964	5 year average	1960	1961	1962	1963	1964	5 year average	1960	1961	1962	1963	1964	5 year average
NORTHWESTERN REGION																		
Chicago & North Western	43	27	26	27	29	30	$197	$121	$126	$132	$147	$145	1.55	.80	.88	.91	.98	1.04
Chicago Great Western	73	61	87	75	42	68	247	214	304	268	144	235	2.42	2.04	2.89	[illegible]	1.38	[illegible]
Chicago, Milwaukee, St. Paul & Pacific	28	15	26	26	17	22	112	62	109	110	72	93	.93	.51	.87	.86	[illegible]	[illegible]
Duluth, Missabe & Iron Range	60	19	75	33	40	45	275	72	334	149	87	183	2.00	.65	2.52	1.11	1.34	[illegible]
Duluth, Winnipeg & Pacific	34	38	37	39	46	39	117	145	130	99	139	126	1.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Great Northern	51	51	49	54	56	52	245	240	235	266	262	250	1.59	1.61	1.58	1.74	1.81	1.67
Green Bay & Western	14	14	10	11	15	13	52	49	42	27	53	45	.49	.49	.34	.37	[illegible]	.44
Lake Superior & Ishpeming	45	28	83	71	25	50	121	78	265	212	78	151	1.80	1.11	3.41	2.38	.85	1.91
Minneapolis, Northfield & Southern	81	89	34	48	63	63	336	373	135	193	255	258	3.38	3.68	1.40	2.01	2.61	2.62
Northern Pacific	56	51	53	53	52	53	211	71	208	205	196	178	1.94	1.77	1.53	1.82	1.81	1.83
Soo Line	14	24	23	37	43	28	49	204	82	130	162	125	47	.80	.77	1.21	1.43	.94
Spokane International	97	94	51	82	11	67	393	429	230	368	45	293	3.30	3.22	1.74	[illegible]	.37	2.28
Spokane, Portland & Seattle	86	59	61	52	58	63	362	262	268	226	251	274	2.80	1.93	1.99	1.68	1.87	2.05
Total	43	34	38	39	38	38	180	143	164	170	160	163	1.43	1.13	1.27	1.31	1.25	1.28
CENTRAL WESTERN REGION:																		
Atchison, Topeka & Santa Fe	21	25	23	28	42	28	62	80	79	95	148	93	.66	.77	.72	.87	1.31	.87
Chicago, Burlington & Quincy	17	22	25	25	33	24	61	79	92	92	128	90	.56	.72	.82	.80	1.06	79
Chicago, Rock Island & Pacific	40	46	47	49	46	46	114	147	148	160	146	143	1.34	1.56	1.57	1.65	1.53	1.53
Colorado & Southern	59	21	30	52	59	44	234	90	123	206	225	176	2.01	.73	1.02	1.76	1.99	1.50
Colorado & Wyoming	13	23	14	15	15	16	46	88	63	63	59	64	.40	.71	.43	.48	.46	.50
Denver & Rio Grande Western	21	33	17	28	46	29	93	143	70	117	184	121	.69	1.06	.55	.92	1.50	.94
Fort Worth & Denver	62	20	32	29	27	34	234	71	116	99	89	122	2.07	.66	1.05	.95	.91	1.13
Northwestern Pacific	64	48	30	28	4	35	206	169	106	101	14	119	2.25	1.70	1.06	.98	.13	1.22
Pacific Electric	48	-	29	17	27	24	124	-	70	40	65	60	1.42	-	1.00	.66	1.07	.83
San Diego & Arizona Eastern b	-	-	-	41	37	39	-	-	-	99	88	94	-	-	-	1.43	1.30	1.37
Southern Pacific Co.	54	46	51	54	46	50	182	156	171	180	143	166	1.79	1.52	1.69	1.78	1.53	1.66
Toledo, Peoria & Western	22	24	18	34	46	29	84	71	54	92	154	91	.69	.74	.55	1.07	1.46	.90
Union Pacific	62	47	57	52	39	51	251	195	244	219	163	214	2.20	1.63	2.02	1.85	1.38	1.82
Western Pacific	71	54	59	52	44	56	349	273	288	284	257	290	2.37	1.80	1.97	1.73	1.46	1.87
Total	39	36	39	40	41	39	138	130	142	147	148	141	1.27	1.19	1.28	1.33	1.36	1.29
SOUTHWESTERN REGION																		
Kansas City Southern	53	40	26	63	60	48	168	123	79	197	187	151	1.68	1.26	.82	2.00	1.91	1.53
Kansas, Oklahoma & Gulf	28	46	-	59	173	61	80	128	-	170	696	215	.95	1.52	-	1.94	5.79	2.04
Louisiana & Arkansas	63	68	43	104	117	79	192	210	131	325	370	246	1.93	2.09	1.31	3.19	3.58	2.42
Missouri-Kansas-Texas	58	45	32	58	141	67	196	154	110	201	494	231	1.81	1.42	1.02	1.83	4.42	2.10
Missouri Pacific	68	39	54	58	60	56	223	124	175	189	206	183	2.19	1.26	1.76	1.89	1.93	1.81
Quanah, Acme & Pacific c	-	7	32	17	11	17	-	24	139	67	47	69	-	.24	1.02	.52	.36	.54
St. Louis-San Francisco	84	44	76	59	60	65	250	136	233	183	188	198	2.67	1.41	2.43	1.88	1.92	2.06
St. Louis Southwestern	43	51	63	70	80	61	135	166	215	239	289	209	1.42	1.67	2.07	2.28	2.63	2.01
Texas & Pacific	32	17	23	30	39	28	99	54	74	102	134	93	1.08	.57	.77	1.03	1.33	.96
Texas Mexican	42	53	46	41	85	53	130	169	128	113	204	149	1.34	1.66	1.45	1.28	2.68	1.68
Total	61	40	52	58	72	57	195	129	166	189	245	185	2.00	1.30	1.67	1.88	2.33	1.84
Grand Total - United States	43	35	40	41	44	41	161	135	155	157	174	156	1.43	1.16	1.32	1.34	1.43	1.34
CANADIAN ROADS:																		
Canadian National	62	59	51	46	43	52	176	175	141	136	144	154	2.12	2.00	1.70	1.60	1.5	1.8
Canadian Pacific	70	62	59	61	54	61	216	183	167	174	168	181	2.43	2.15	2.01	2.08	1.83	2.09
Ontario Northland	122	98	151	93	68	106	477	400	583	375	292	425	4.11	3.29	5.03	2.99	2.28	3.54

a Includes New York, Chicago & St. Louis merged with Norfolk & Western and Pittsburgh & West Virginia and Wabash leased by N&W effective Oct. 16, 1964.
b Not Class I prior to January 1, 1963. Data for prior years not available.
c Not Class I prior to January 1, 1961. Data for prior years not available.

Compiled by
Association of American Railroads, Bureau of Railway Economics, Washington, D.C.,
from Annual Reports of Class I railroads to the Interstate Commerce Commission.

May 1965

MEMOIR

John Edwin Armstrong

Died December 4, 1964

John Edwin Armstrong, retired chief engineer of the Canadian Pacific Railway and past president and Honorary Member of the American Railway Engineering Association, died in Montreal, Que., on December 4, 1964, at the age of 78.

Mr. Armstrong was born on September 29, 1886, at Peoria, Ill., and attended Bradley Polytechnical Institute before entering Cornell University, from which he received a degree in civil engineering in 1908. On December 26, 1908, he was married to Jane Drake Wilson at Ithaca, N. Y. Although they spent most of their lives in Canada, they maintained a summer residence near Ithaca until Mrs. Armstrong's untimely death in 1952. They are survived by a son, John E. Armstrong, Jr., of Pointe Claire, an assistant engineer on the Canadian Pacific until his recent retirement; a daughter, Mrs. Eugene Wade, of Toronto, Ont., and a grandson, John Armstrong, of the Town of Mount Royal, Que.

John Edwin Armstrong

John E. Armstrong obtained his first railway experience during summer vacations, serving in both the engineering and mechanical departments on the Toledo, Peoria & Eastern Railroad. His first job after graduation was that of assistant on the engineer corps of the Pennsylvania Railroad at Cleveland, Ohio, where he remained until he migrated to Canada.

He joined the Canadian Pacific in 1912 as an assistant engineer at Montreal, and was named assistant chief engineer in 1928. As chief engineer, from 1939 until his retirement in 1951, he was busily engaged in solving many of the complex engineering problems attendent to maintaining the company's coast-to-coast rail lines during the Second World War, when labor and materials were in short supply and freight and passenger volume was tremendously increased.

During his tenure as chief engineer, the Canadian Pacific's $14 million St. Luc hump-retarder marshalling yard at Montreal, first of its kind in Canada, was constructed and many miles of automatic block signals were installed across the continent.

In spite of the heavy duties of his professional position he found time to participate in the activities of various societies. There were three organizations to which he made special contributions—the American Railway Engineering Association, the Engineering Institute of Canada and the Canadian Standards Association.

John E. Armstrong became a member of the AREA in 1920 and was soon actively engaged in committee work, becoming a member of Committee 14—Yards and Terminals, in 1921, and continuing on that committee until 1948. He served as its chairman from 1928 to 1931. Other committee service included Committee 4—Rail, 1926–1950; Committee 28—Clearances, 1928–1950; Committee 26—Standardization, 1928–1932 and 1937–1942; and the Special Committee on Complete Roadway and Track Structure, 1937–1940. He served as chairman of the latter committee in 1938 and 1939. In addition, he served on the Committee on (convention) Arrangements, becoming a member of that important committee in 1925. Mr. Armstrong was made an honorary member of the committee on November 5, 1954, by action of the Board of Direction. However, he had been accorded this honor unofficially by the members of the committee in March 1946.

It was also in 1925 that Mr. Armstrong was brought emphatically to the attention of the Association as the result of an address he gave before the New England Railroad Club. J. M. R. Fairbairn, chief engineer of the Canadian Pacific and at that time president of the AREA had been invited to appear before the club on the evening of November 10, but because of ill health he was unable to fill the engagement and Mr. Armstrong spoke in his stead. His subject was "The American Railway Engineering Association," and what he told his audience that evening proved to be by far the most complete and authoritative account of the objectives and functions of the AREA that had been offered by anyone up to that time. It was subsequently published as a monograph in AREA Bulletin 285 and in Proceedings Volume 27, 1926.

Mr. Armstrong became a member of the AREA Board of Direction late in 1927 to fill an unexpired term, and that election set in motion a train of circumstances that has been unparalleled in the history of the Association. Upon the completion of the partial term in March 1929, he was elected to the Board in his own right to serve a regular three-year term. He was elected vice president of the Association in March 1932 and president in March 1934.

Until 1948, the AREA Constitution provided that the membership of the Board of Direction include the five junior past presidents (instead of two, as at present). Thus Mr. Armstrong looked forward to five more years on the Board following the end of his term as president in March 1936. However, one year was added by a World War II measure under which President H. R. Clarke's term was increased to two years and four more years were added by the death in office of President G. S. Fanning and the demise, in turn, of three past presidents junior to Mr. Armstrong. They were: J. C. Irwin, R. H. Ford and F. L. C. Bond. As the result of these circumstances, Mr. Armstrong enjoyed the unusual distinction of having served the Association as a member of its governing today a total of almost 17½ years.

His long tour of duty with the Board of Direction, his faithful service on standing committees and his active participation in the work of the Committee on Arrangements afforded him an exceptional opportunity to become well informed concerning all facets of the Association's aims and procedures. He also developed a keen and sympathetic interest in the work of the secretary and the members of his staff and gained an insight into the many problems that confronted them. It was because of this understanding that he took upon himself the task of preparing an historic record of committee service in the form of a book in which each member's part in committee work was recorded, showing not only the years he served on each committee but also any service as chairman or vice chairman. The value of this record to the Board Committee on Personnel was recognized at once and although the basic plan has since been applied to a card index system, the original volume is still in use.

Mr. Armstrong joined the Engineering Institute of Canada in 1917 and served on its finance committee from 1939 to 1947. He was vice president of the Institute in 1945–46, was president during 1949–50, and was made an honorary member in 1955. During his presidency he traveled more than 35,000 miles, visiting every branch of the organization between the shores of Newfoundland and British Columbia, and was instrumental in the opening of many new branches.

His most noteworthy work for the Institute was chairmanship of a special committee on the engineering features of civil defense in 1942, working closely with Professor Fred Webster, who, as Great Britain's expert on the effects of bombing, visited Canada for several months in that year. His committee set up Organized Engineering Groups across Canada and assembled valuable information on transportation which would have been vital had Canada been bombed. For his great contributions in this area, the Institute awarded him the Julian C. Smith Medal.

In the Canadian Standards Association, he was assigned to committee work in 1941 and appointed a member of the Executive Committee in 1945. Mr. Armstrong continued as a useful member of the CSA until his retirement from the Canadian Pacific.

In addition to these activities and accomplishments, he was active in the Canadian Railway Club, serving as its president in 1940.

John E. Armstrong had many talents and made good use of them.

Report of the Executive Secretary

March 1, 1965

To the Members:

The 66th year of the American Railway Engineering Association was one of change and accomplishment—change in the Association's top administrative position and in the pattern of Annual Meetings; accomplishment in successfully progressing a number of highly important projects and functions of the Association.

Without a doubt the top AREA news story of 1964 was the retirement on July 31 of Neal D. Howard as executive secretary, and the appointment of Earl W. Hodgkins as his successor. Mr. Howard had been secretary and executive secretary for more than 14 years, serving the Association with devotion, dedication and distinction during a period of great technological and economic change on American railroads, each of which influenced the conduct of Association affairs. On November 6, the Board of Direction elected Mr. Howard to the honorary position of Executive Secretary Emeritus.

Another change that should be noted for the record relates to the AREA's dual capacity as the Engineering Division, Association of American Railroads. Since 1918, when the dual capacity was inaugurated, the AREA has in addition to its existence as an independent Association of individuals served as an integral part of the Operations and Maintenance Department, AAR. It functioned first as the Construction and Maintenance Section of the Engineering Division and since January 1, 1961, has functioned as the whole Engineering Division.

As such, it has operated under Curtis D. Buford, vice president of the Operations and Maintenance Department, since 1959. On August 31, 1964, Mr. Buford resigned to become executive vice president of the Pittsburgh & Lake Erie Railroad and was succeeded by Rex R. Manion, formerly vice president of the New York Central System and a former director of the AREA. Mr. Buford is now president of the P&LE, being elected to that position on January 1, 1965.

1964 Convention

After 2 years of restricted-length conventions, the AREA in 1964 returned to its normal 2½-day Annual Meetings. This affair was held on March 9–11 at the Pick-Congress Hotel, Chicago, and was attended by 655 railroad members and guests and 384 non-railroad members and guests—a total of 1039. In addition, 135 ladies attended.

The 1964 convention, which also was the Annual Meeting of the Engineering Division, AAR, followed the same pattern as the full-scale meetings held previous to the 1962 restricted convention, that is, special features and the Annual Luncheon were returned to the program to supplement the Annual reports of each of the Association's 22 standing and special technical committees. In all, there were 19 special features interspersed among the committee presentations. These included addresses, illustrated papers and motion pictures.

One of the features was the Keynote Address, which was delivered at the opening session by Mr. Buford. He talked on Engineering Our Future. Another was the principal feature of the Annual Luncheon—an address by B. S. Sines, vice president, Southern Pacific Company, on Transportation Goals.

As usual, the Annual Luncheon was the main social function of the convention and was held on the second day. A total of 687 members and guests attended.

COMMITTEES OF THE BOARD OF DIRECTION

1964–1965

Executive Committee

T. F. Burris (Chairman), A. V. Johnston, C. J. Code, J. M. Trissal, L. A. Loggins

Assignments

A. V. Johnston (Chairman), C. J. Code, B. B. Lewis, A. L. Sams, L. A. Loggins

Personnel

W. L. Young (Chairman), J. M. Trissal, John Ayer, Jr., H. M. Williamson, J. S. Parsons

Publications

C. E. Defendorf (Chairman), D. C. Hastings, S. H. Poore, J. S. Parsons, H. E. Wilson

Manual

John Ayer, Jr, (Chairman), T. B. Hutcheson, S. H. Poore, F. N. Beighley

Membership

T. B. Hutcheson (Chairman), C. E. Defendorf, D. C. Hastings, B. B. Lewis, F. N. Beighley

Finance

J. M. Trissal (Chairman), A. V. Johnston, A. L. Sams, H. M. Williamson, H. E. Wilson

Research

C. J. Code (Chairman), R. H. Breeder, Ray McBrian, H. M. Williamson, W. L. Young

---

Approves principle of regional meetings

At its meeting on November 6, the Board of Direction took an historic step by giving its approval to the principle of holding regional meetings in various parts of the country remote from Chicago, site of the Association's Annual Conventions. However, not more than one regional meeting will be permitted in any one year.

The purpose of regional meetings is to stimulate interest in the AREA on the part of members who seldom if ever have the opportunity of attending an Annual Convention. This could be accomplished by participation in a meeting in their general geographical area. In addition, it is hoped that regional meetngs will attract non-members who by their attendance will become aware of the high caliber of AREA members and activities, thus stimulating them to become members and take an active part in Association affairs.

It should be emphatically pointed out that regional meetings will not take the place of the Annual Meeting at Chicago or meetings of the Association's technical committees. No Association business will be transacted at them. The program will be strictly informational in that it will consist of papers, discussions and motion pictures or slides on problems or activities common or of interest to railway engineers residing in a particular area. In fact, the attendance at any regional meeting will be drawn only from railroads in or serving that particular region. The only exception will be the possible attendance of a few AREA executive officers.

The Board also voted to hold a pilot regional meeting in 1965, probably in October, in the West Coast–Pacific Northwest area. H. M. Williamson, an AREA director and chief engineer system, Southern Pacific, was appointed chairman of the pilot meeting. Mr. Williamson has taken steps to determine the best location for the meeting, estimated attendance from railroads in or serving the area, and timely and interesting features for the program.

Continuous Welded Rail Committee given permanent status

Another action by the Board of Direction on November 6 was the voting of permanent status to the Special Committee on Continuous Welded Rail. Henceforth, it will be known as Committee 31—Continuus Welded Rail. The first chairman of the new standing committee is W. J. Jones, engineer maintenance of way and structures, Southern Pacific. The Special Committee was organized in 1950.

Four Committee 24 projects progressed

During 1964, one major project of Committee 24—Cooperative Relations with Universities, was brought to a successful conclusion, two others gained impetus and a fourth again helped to bridge the gap between engineering students and railroads.

Late in September the Third Edition of the Association's Engineer Recruiting Brochure, entitled "The Railroad Industry—A Challenge and Opportunity for Engineering Graduates," came off the presses. A total of 21,250 copies were printed, most of them destined to be furnished to colleges and universities in the United States and Canada during the next 4 or 5 years for free distribution to interested engineering sudents. Already approximately 4,000 have been distributed. In addition, 5,120 were purchased by railroads for use in their training programs, some with AREA covers and others without covers to which the ordering road applied its own covers.

The 1964 popularity of another major project of Committee 24, the Pictorial Railroad Exhibit, has been unparalleled in its three-year history. Starting in March when it was displayed at an Engineering Open House Exposition at the University of Illinois, the Exhibit has not remained in the secretary's office very long. It spent the summer in Portland, Ore., where it was part of a Transportation Club Exhibit at the Oregon Museum of Science and Industry. Last fall it was used by the Michigan Technological University at a Transportation Conference. Subsequent to these engagements, the Exhibit has been or will be displayed at the Ecole Polytechnique in Montreal, Que., University of California at Los Angeles, Cornell University, Newark College of Engineering, Pennsylvania State University and Iowa State University. Unfortunately the requests of eight other institutions desiring the Exhibit had to be denied because these prior commitments completely filled up the schedule for the spring semester.

Still another project of this committee that aids the image of the Association and keeps the railroad industry before engineering students is its program of arranging for speakers from railroad engineering and maintenance of way departments to address engineering groups, both civil, transportation and industrial. Addresses given up to December 31 are described in the Annual Report of Committee 24, which was published in Bulletin 590, January 1965. Several have since been given and a number will yet be presented this semester.

The project to bring engineering students to the railroads for summer employment in 1964 was sponsored by Committee 24, as it has been for a number of years. A questionnaire was circulated to all AAR member roads requesting information on summer employment needs. The data were compiled by W. A. Oliver, professor of civil engineering, University of Illinois, and the pertinent information transmitted by the secretary's office to about 125 colleges and universities, taking into account any special requests or restrictions regarding its participation by any of the railroads. The questionnaire seeking information on 1965 summer employment needs of railroads has already been mailed.

MEMBERSHIP

An area that needs immediate attention by all members is membership. Actually this is a function in which members can never relax if they want a healthy, progressive Association. However, it becomes particularly important when the previous year showed a 2 percent drop in membership, as did 1964 when compared with 1963. These statistics are given in the accompanying tabulation. Although this is not serious at the present time, primarily because the comparison is being made with a year in which a concentrated membership effort was made, each member should accept the challenge to bring in new members to reverse the dirction of the movement before it becomes a trend. This should not be too difficult because the Association has so much to offer its members, particularly the younger railway engineers and supervisors.

Membership

(*Membership year extends from February 1 to January 31*)

	Membership Year	
	1963	*1964*
Members as of February 1, 1963 (beginning of Membership Year)...	3261	
Members as of February 1, 1964 (beginning of Membership Year)...		3398
New Members during year	307	140
Reinstatements during year	48	19
Gain or loss in Junior Members	13	—14
	3629	3541
Deceased during year	59	50
Resigned during year	55	51
Dropped during year	117	108
	231	209
Net gain or loss	137	—66
Membership January 31, 1964 (end of Membership Year)	3398	
Membership January 31, 1965 (end of Membership Year)		3332

Membership Classification by Years

(*For each of the membership years shown, the year begins on February 1, and ends on January 31 of the following year*)

	1957	*1958*	*1959*	*1960*	*1961*	*1962*	*1963*	*1964*
Life	469	482	481	474	490	489	465	449
Member	2524	2491	2527	2554	2467	2434	2573	2540
Associate	268	251	264	288	301	261	270	267
Junior	101	86	101	91	89	77	90	76
Totals	3362	3310	3373	3407	3347	3261	3398	3332

An analysis of the accompanying tabular material for 1963 and 1964 shows that about half of the loss occurred in the Member category, with the remaining loss divided almost equally between the Life and Junior classes of membership. Not much can be done about the Life Members—this is the attrition to which we are all susceptible.

But, how about the Member and Junior categories? Why should these show a drop except in years a concentrated membership effort is made? It can't be the membership dues, they are minima—$15 for the former and only $5 for the latter. Is it because eligible men are not made aware of the worth and advantages of AREA membership and after joining are not encouraged to become active on a committee and maintain their good standing by paying dues annually? Or, do those who drop out feel they aren't getting their money's worth? In 1964 alone, 159 members either resigned from the AREA or were dropped for non-payment of dues. Why? Certainly not all of them left the industry—this is usually a small percentage. These are questions only the individual members can answer, particularly the chief engineering and maintenance officers on the railroads.

The questions are posed seriously. The answers and the solutions of the problems determined therefrom are vital if the Association is to maintain a healthy condition and continue to progress in its efforts to serve the railroad industry.

Student Affiliates

Not included in the foregoing membership tabulation are the Student Affiliates enrolled in the AREA from college campuses. As of January 31, 1965, the Association had 43 Student Affiliates on 25 different campuses, compared with 46 at 19 locations one year earlier.

During the 5-year life of the Association's Student Affiliate program from late 1960 to January 31, 1965, cumulative figures show 150 Student Affiliates have been enrolled from 40 different colleges or universities in the United States and Canada. The accompanying tabulation (see page 6) presents this information in the Secretary's Report for the first time.

It is obvious that if the Student Affiliate program is to continue a new effort will be required at the beginning of and during each school year. Of course, this is necessitated by the partial turnover of students each year—upperclassmen and graduate students completing their studies and new students enrolling in the colleges and universities. It is hoped that each year faculty members, current Student Affiliates and railroad members visiting college campuses will promote the program and encourage interested students to become affiliated with the Association.

Accordingly, the secretary's office will continue its efforts in this regard during the 1965–66 school year. In addition, it will continue to request railroad engineering officers speaking on college campuses to apprise the students of the valuable, low-cost AREA affiliation which is open to them.

Past President J. E. Armstrong dies

During the year ending January 31, 1965, there were 50 deaths among the membership, nine less than the previous year. The names of these members are listed in the roster of deceased members immediately following this report.

Unfortunately, one of the losses was **John E. Armstrong** (M '20), a past president (1934–35) and Honorary Member of the Association, who died on December 4, 1964,

STUDENT AFFILIATES ON COLLEGE CAMPUSES

College or University	*Number Enrolled 1960 to 1/31/65*	*Current Number Enrolled*
Auburn University	2	..
*University of British Columbia	3	..
Brooklyn Poly. Institute	8	3
University of Colorado	2	1
University of Connecticut	1	1
Cooper Union	1	1
University of Denver	1	..
Georgia Institute of Technology	2	..
Harvard University	1	1
*Illinois Institute of Technology	6	1
*University of Illinois	31	11
*Iowa State University	3	2
Laval University	1	1
*Lehigh University	1	1
Louisiana Poly. Institute	4	1
Louisiana Technological University	1	..
University of Manitoba	13	3
*Marquette University	3	1
*Massachusetts Institute of Technology	11	2
*University of Michigan	5	1
*Michigan Technological University (Formerly Michigan College of Mining and Technology)	4	2
University of Nebraska	2	1
University of New Brunswick	2	..
*New York University	2	..
Northeastern University	1	1
*Northwestern University	1	1
Ohio Northern University	1	..
*Ohio State University	...	1
Princeton University	3	1
*Purdue University	6	2
*Rensselaer Poly. Institute	5	..
San Jose State	1	..
*South Dakota School of Mines and Technology	3	1
Southern Illinois University	1	..
Southern Methodist University	1	..
*Stanford University	2	1
*University of Tennessee	9	1
University of Texas	3	..
*University of Washington	1	..
Yale University	1	..
Total Since 1960 . . . 40 Universities	150	
Current Total . . . 25 Universities		43

---

*Means at least one professor is a member of AREA

Number in current column is included in cumulative column

Some of the above have become student affiliates for only 6 months, others for one year, and still others for more than one year.

at Montreal, Que., at the age of 78. Mr. Armstrong was chief engineer of the Canadian Pacific Railway before his retirement in 1951. He was a member of Committee 4—Rail, 1926–50, a member of Committee 14—Yards and Terminals, 1921–48, of which he was chairman, 1928–31, a member of Committee 28—Clearances, 1928–50, a member of Committee 26—Standardization, 1928–32 and 1937–42, and a member of the Special Committee on Complete Roadway and Track Structure, 1937–40, of which he was chairman, 1938–39.

In addition to Mr. Armstrong, who served as a director from 1927 to 1932, eight other past directors died within the 1964 membership year. These are **R. C. Bardwell** (M '17), retired superintendent water supply, Chesapeake & Ohio, who was a director, 1934–36, a member of the General Convention Arrangements Committee, 1928–53, of which he was chairman in 1931, 1934 and 1953, and an Honorary Member of the committee since 1954, a member of Committee 13—Water, Oil and Sanitation Services, 1918–53, of which he was chairman, 1931–37, and a Member Emeritus since 1953, and a member of the Special Committee on Clearances, 1931–37; **C. B. Bronson** (M '24), retired assistant chief engineer maintenance of way, New York Central, who was a director, 1949–51, a member of Committee 4—Rail, 1925–56, of which he was chairman, 1946–48, and a Member Emeritus since 1956, a member of the Special Committee on Stresses in Railroad Track, 1925–41, and a member of the Special Committee on Continuous Welded Rail, 1952–58; **W. J. Burton** (M '07), retired assistant to chief engineer, Missouri Pacific, who was a director, 1934–36, a member of Committee 3—Ties, 1912–55, of which he was chairman, 1926–35, and a Member Emeritus since 1956, a member of Committee 4—Rail, 1937–55, a member of the Special Committee on Stresses in Railroad Track, 1920–40, and a member of the Committee on Research Administration, 1941–43; **Maurice Coburn** (M '05), retired assistant engineer, Pennsylvania, who was a director, 1922–24, a member of Committee 6—Buildings, 1906–14, of which he was chairman, 1912–14, a member of Committee 8—Masonry, 1933–53, and a Member Emeritus since 1954, a member of Committee 16—Economics of Railway Location, 1915–18 and 1931–32, a member of Committee 21—Economics of Railway Operation, 1918–23, and a member of Committee 23—Shops and Locomotive Terminals, 1930; **S. R. Hursh** (M '28), retired assistant vice president, Pennsylvania, who was a director, 1952–54, a member of Committee 4—Rail, 1946–61, a member of Committee 24—Cooperative Relations with Universities, 1946–49, of which he was chairman, 1948–50, and a Member Emeritus since 1959, and a member of the Special Committee on Continuous Welded Rail, 1952–61; **R. A. Van Ness** (M '22), retired bridge engineer, Atchison, Topeka & Santa Fe, who was a director, 1942–45, a member of Committee 8—Masonry, 1927–29, a member of Committee 15, 1930–48, of which he was chairman, 1938–40, and a member of Committee 26—Standardization, 1938–40; **W. D. Simpson** (M '20), retired chief engineer, Seaboard Air Line, who was a director 1947–49, a member of Committee 3—Ties, 1938–48, of which he was vice chairman, 1941–45, a member of Committee 4—Rail, 1946–61, a member of Committee 17—Wood Preservation, 1921–22, a member of Committee 20—Contract Forms, 1929, and a member of Committee 25—Waterways and Harbors, 1952–57; and **C. H. Blackman** (M '13), retired chief engineer, Louisville & Nashville, who was a director, 1946–48, a member of Committee 4—Rail, 1942–51, Committee 7— Wood Bridges and Trestles, 1921–24, Committee 14—Yards and Terminals, 1925–33, and Committee 16—Economics of Railway Location and Operation, 1940–54, of which he was chairman, 1948–50, and a Member Emeritus since 1954.

A number of other members who died during the year had unusually long committee service records. They are: **M. C. Blanchard** (M '14), retired chief engineer, Atchison, Topeka & Santa Fe, who was a member of Committee 5—Track, 1917–19, Committee 8—Masonry, 1932–33, Committee 13—Water, Oil and Sanitation Services, 1915–17, Committee 21—Economics of Railway Operation, 1922–24, and Committee 22—Economics of Railway Labor, 1926; **A. R. Dewees** (M '15), retired division engineer, Pere Marquette, who was a member of Committee 3—Ties, 1925–27, and Committee 9—Highways, 1932–46; and **W. M. Ludolph** (M '31), retired assistant engineer, Chicago, Milwaukee, St. Paul & Pacific, who was a member of Committee 11—Records and Accounts (now Engineering and Valuation Records), 1933–61.

Among the oldest members of the Association who died during the year were **Mr. Coburn,** 1905, **Mr. Burton,** 1907, and **J. H. Nuelle,** retired president, Delaware & Hudson, who joined the AREA in 1911.

ACTIVITIES OF COMMITTEES

Personnel of Committees

Reflecting the generally better business conditions on the railroads last year, the number of members assigned to committees during 1964 was greater than in 1963. Specifically, throughout the year there were 1151 members regularly assigned to 1244 places on the Association's 22 standing committees. This compares with 1118 members who occupied 1202 places on these same committees during the previous year. In addition to their regular members during 1964, practically all committees again carried "guest" members on their rosters—members assigned during the year on a guest basis, awaiting regular assignment with the official roster change to become effective with the close of the 1965 Annual Convention.

Again, AREA committees were limited to a maximum membership of 70, including Members, Associate and Junior Members, but not including retired members and Member Emeritus, and to the number of members from each railroad, depending on the total number of AREA members from a specific railroad. However, to meet the desire of the Association of American Railroads for relatively small AAR committees, there was continued in 1964 the plan adopted by the General Committee, Engineering Division, in 1961, which provides that the chairmen, vice chairmen, secretaries and all subcommittee chairmen—to the extent that they are in the active employ of railroads—alone constitute the official Engineering Division committees within the larger AREA committees. In 1963, a rule was adopted that only members of committees who are in the active employ of the railroads should be chairmen of subcommittees with assignments dealing with railroad or Association policy matters, assignments calling for expenditures on the part of the railroads, or assignments which might occasion dealing with public officials or agencies.

Again, to set apart as a group the Engineering Division committee within each AREA committee—for convenience and record purposes—the names of those on the Engineering Division committee were grouped at the head of the list of personnel of the committee as a whole, as presented in the Committee Assignments Pamphlet and the Bulletins, and were set in bold-face type.

Reflecting, unmistakably, the continued interest of members in serving on committees, and of their railroads in being represented on committees, is the fact that the number of members assigned to committees for 1965, effective with the official roster changes at the end of the 1965 Annual Convention, will be up slightly from 1964. Specifically, 1187 members have been assigned to 1266 places on committees for 1965.

Work of Committees

During 1964 the 22 technical committees of the Association worked on 179 assignments, 17 of which were new. In their work they continued to follow much the same pattern as in previous years, their different subcommittees carrying out their own studies and investigations independently, or with the cooperation of the research staff of the Association of American Railroads, looking to the preparation of progress or final reports for information; of revising material appearing in the AREA Manual of Recommended Practice, the AAR Electrical Manual, and the Portfolio of Trackwork Plans; or of developing new Manual and Portfolio material; and of carrying out special projects related to their assignments. That the work accomplished by committees was again substantial is seen in the fact that they produced one or more reports on 116 of their 179 assignments (not including Assignments A), 13 of which were final reports and 24 of which contained Manual recommendations. Furthermore, all committees presented brief "progress" or "status" statements with respect to assignments on which they made no formal report.

Classification of Material Produced by Committees

The work of committees during the year was again so diversified and extensive that it is impossible to do other than refer to it in general terms in a report of this character. But there is presented in the following a general categorical classification of the results of this work, as published in the Bulletins of the Association, and to be presented to the 1965 convention:

Recommendations pertaining to the development, revision, deletion or reapproval without change, of 46 different specifications and recommended practices for inclusion in the AREA Manual and the AAR Electrical Manual; 73 reports on current developments in engineering practice and design; 7 reports dealing with economy in the use of labor and the recruiting and training of employees; 4 reports on new and improved power tools, machines, materials and equipment; 3 reports involving statistics; 5 economic and analytical studies; 3 reports on relations with public authorities; and 2 bibliographies.

The work of committees affecting the AREA Manual included the presentation of 2 specifications for adoption and 4 as tentative; the rewriting or revision of 7 specifications, with or without reapproval (1 in the Electrical Manual); the presentation of 5 recommended practices for adoption and 2 as tentative; the revision or rewriting of 10 recommended practices, with or without reapproval (1 in the Electrical Manual); the reapproval of 1 recommended practice without change; the deletion of 6 recommended practices; the adoption of 3 agreement forms; the presentation of 1 tentative agreement form; the revision of 1 trackwork plan; and the deletion of 2 trackwork plans.

During 1965, the committees as a whole will work on 186 assignments, 23 of which are new.

Committee Meetings

In carrying out their work during 1964, the 22 technical committees of the Association held a more normal number of meetings compared with 1963 when they held the smallest number of meetings in many years. However, of the 1964 meetings, 12 were in reality executive sessions held in Chicago during the 1964 convention and attended in large part alone by the committee officers and subcommittee chairman. Such meetings were not held during the 1½-day Business Meeting in March 1963. The large majority of the 1964 meetings were again held in Chicago or at points central to the largest number of committee members. The exceptions were scheduled to permit inspections of facilities or operations which could be seen only by going to those points.

Specifically, a total of 65 committee meetings were held during the Association year ended March 1, 1965. This compares with 54 meetings held during the year ended March 1, 1964, and 63 meetings held the year earlier.

Of the 65 meetings held during the 1964 Association year, 36 were held in Chicago (including the 12 held during the 1964 Convention); 4 were held in St. Louis, Mo.; 3 each in New York City and Toronto, Ont.; 2 each in New Orleans, La., Norfolk, Va., and Baltimore, Md.; and 13 were held in other cities. Dictated by the scope of their work and other considerations, 4 committees each held 4 meetings; 15 committees each held 3 meetings, 1 committee held 2 meetings, and 2 committees each held only 1 meeting. Combined with their meetings, 19 inspection trips were made by committees during the year to see facilities, structures, procedures or operations directly related to their work.

ASSOCIATION PUBLICATIONS

Compared with the previous year, 1964 was a considerably bigger publication year, principally because it was necessary to reprint in its entirety the Association's Portfolio of Trackwork Plans to replenish an exhausted supply. Also, with the return to a 2½-day convention in March 1964, with a full complement of illustrated special features, after two years of 1½-day restricted-program business meetings, the June–July Convention Issue of the Bulletin was substantially larger than for each of the last two years. However, the Association again made widespread distribution of its various publications, far beyond its own membership.

Copies of the 1964 Supplement to the AREA Manual, containing 210 pages, were made available early in August and were mailed automatically to all member holders of the Manual who had paid the $1.00 annual Supplement fee. At the same time nonmember holders of the Manual were notified of the availability of the Supplement and the price thereof. Later, continuing a practice started several years ago, the secretary's office mailed direct to all committee members, without charge, copies of the 1964 Supplement sheets pertaining to the Manual chapters sponsored by the committee or committees of which they were members. This was again to permit committee members who have purchased separate copies of their committee's Manual chapter to keep those chapters up to date.

Copies of the 1964 Supplement to the AAR Electrical Manual of Standards and Recommended Practice, consisting of 26 pages, was also made available early in August.

The 1964 Supplement to the Portfolio of Trackwork Plans consists of only one plan, and as an economy measure was printed as a continuation of the press run for that plan during the reprinting of the entire Portfolio. Copies of the plan were sent to holders of the Portfolio without charge early in November.

Again in 1964, the Association dispensed with the publication of the annual bound volume of the Proceedings—a practice begun in 1961. In place of the bound volume, all of the Bulletins of the Association from the September–October 1963 issue through the June–July 1964 issue were punched for binding, and all members who had made prior requests were furnished, without charge, a two-post, hard-cover, book-type binder, similar in every respect to the binders issued in 1961, 1962, and 1963 in which to house as a unit their copies of the Bulletin. Thus, again, without the former duplication of material in the Bulletins and the Proceedings, members were able to assemble in neat bound form all of the Bulletins for the publication year, including the complete proceedings of the 1964 Annual meeting of the Association, which appeared in the June-July issue. The only exception is the March Year Book Bulletin which was not punched for binding since the Directory of Members has never been published in the Proceedings.

In addition to these regular AREA and AAR Engineering Division publications, the Association published the Third Edition of its Engineer Recruiting Brochure as mentioned earlier in this report. The latest edition was entitled "The Ralroad Industry—A Challenge and Opportunity for Engineering Graduates," and again was sponsored by Committee 24—Cooperative Relations with Universities. The First Edition was published in 1955 and the Second Edition in 1959.

RESEARCH WORK

As the 1964 research budget for the AAR Engineering Division was almost $20,000 above the 1963 allotment ($286,000 to $268,000), so the 1965 research budget of $306,100 is exactly $20,000 above the 1964 figure. Although the trend is in the right direction each of these figures is a far cry from the $570,609 budget for 1958.

Once again work on many AAR-AREA committee-sponsored projects now under way will continue to be curtailed and the undertaking of a number of new projects will be further delayed. Why? Because the appropriation for 1965 is 35 percent, or $167,200, below the budget request approved by the General Committee of the Engineering Division (Board of Direction, AREA). In addition, the total appropriation is $47,000 below the total amount requested to adequately progress the "A"-priority projects.

Of the 1965 appropriation of $306,100 and the 1964 expenditure of $286,000 itemized in the accompanying tabulation all but one non-committee expenditure remains the same. They are: Administration of the research office, $35,400, AAR detector car development and leasing, $41,600, and general technical services, $18,300. One item, electrical laboratory and instrumentation, has been increased $1,000 from $27,000 to $28,000.

Comparing the AAR-AREA committee-sponsored-projects appropriations for these two years shows an increase of $19,000 for 1965 over last year, $182,800 to $163,800. Of the 14 committees granted funds 6 were increased, 5 decreased and 3 held to the same level of expenditure. The tabulation also shows 10 new projects or reinstated similar or related projects to be progressed in 1965, and 12 projects for which expenditures were made in 1964 but which will be discontinued in 1965 as having been completed or for other reasons.

For another year, the 5th successive, research reports developed by the Engineering Division will not be published in the AREA Bulletins. The reason is obvious from a quick perusal of the approved budget—once again no appropriation was included to help defray the cost of publishing these reports.

This means that, since the AREA is unable to assume this publication cost in full during 1965, it will again publish only edited and condensed versions of those reports in its Bulletins, along with any recommendations and conclusions. As in the past few years, any disadvantage or loss to members under this arrangement will be offset to some extent by the AAR Research Department producing copies of its complete reports in typwritten, multilith form. Copies of these reports will be provided to the chief engineering and maintenance officers of AAR Member Roads, members of the AAR Engineering Division General Committee (AREA Board of Direction), members of sponsoring AAR-AREA committees; and to others on request to the AAR Research Center.

TOTAL ALLOTMENTS FOR RESEARCH, ENGINEERING DIVISION, AAR, EXCLUSIVE OF DETECTOR CAR DEVELOPMENT AND LEASING SERVICE

1944-1965

1944	$109,050	1955	$351,653
1945	138,110	1956	365,050
1946	159,510	1957	476,845
1947	234,428	1958	563,709
1948	291,840	1959	353,800
1949	372,457	1960	350,300
1950	294,045	1961	222,000
1951	354,770	1962	223,671
1952	381,400	1963	226,400
1953	364,100	1964	244,500
1954	351,307	1965	264,500

SUMMARY OF PROJECTS INCLUDED IN 1965 APPROVED ENGINEERING DIVISION RESEARCH BUDGET, SHOWING EXPENDITURES AUTHORIZED FOR EACH PROJECT, COMPARED WITH ESTIMATED EXPENDITURES FOR PROJECTS IN 1964

	1965 Approved Budget	1964 Estimated Expenditure
Administration		
Research Office	$ 35,400	$ 35,400
Total	$ 35,400	$ 35,400
Committee 1—Roadway and Ballast		
Roadbed Stabilization	$ 15,100	$ 15,100
Vegetation Control	......	600
Total	$ 15,100	$ 15,700
Committee 3—Ties and Wood Preservation		
Further Development of Prestressed Concrete Ties	$ 1,200	$ 700
Termite Control Investigation	1,500	600
Anti-Splitting Devices for Ties	1,000	800
Service Tests of Laminated Ties and Seasoned and Treated Ties	......	400
Total	$ 3,700	$ 2,500
Committee 4—Rail		
Investigation of Failures in Control-Cooled Rail	$ 3,000	$ 3,000
Rail Failure Statistics	4,800	4,800
Insulated Rail Joint Development	3,500	3,500
Shelly Spots and Head Checks	17,000	17,000
Metallurgical Effects of Rail Cropping Methods	2,000	2,000
Semi-Automatic Welding of Rail Batter and Burns	4,600	4,600
Service Tests of Joint Bars	......	1,900
*Tests With 78 Ft. Rail	1,900	......
Total	$ 36,800	$ 36,800

	1965 Approved Budget	1964 Estimated Expenditure
Committee 5—Track		
Prestressed Concrete Crossing Frog Support	$ 400	$ 400
Welding Heat Treated Carbon Steel Frogs and Switches	......	2,000
Specification Development for Tie Plate Fastenings and Tie Pads for Wood and Concrete Ties	6,000	10,000
*Corrosion Protection from Brine Drippings	1,100	......
Slide Plate Lubrication	5,000	5,000
*Bridge Rail Expansion Joints	5,000	......
Total	$ 17,500	$ 17,400
Committee 7—Wood Bridges and Trestles		
*Application of Synthetic Resins and Adhesives	$ 1,000	$ ......
*Strength of Timber Stringers	7,500	......
Non-Destructive Testing of Wood	......	1,500
Field Inspection of Glued-Laminated Construction	......	1,000
Total	$ 8,500	$ 2,500
Committee 8—Masonry		
Shear Keys for Concrete Beams	$ 2,700	$ 2,700
Strength of Prestressed Concrete Beams	......	4,000
Application of Synthetic Resins and Adhesives—Concrete	......	2,000
*Field Inspection of Prestressed Concrete Construction	1,500	......
Total	$ 4,200	$ 8,700
Committee 14—Yards and Terminals		
Rollability of Freight Cars	$	$ 5,000
Coupled-in-Motion Weighing	2,500	2,500
Total	$ 2,500	$ 7,500
Committee 15—Iron and Steel Structures		
Field Inspection of Paint Test Installations	......	$ 1,500
Welding Research—Structures	4,000	5,000
Total	$ 4,000	$ 6,500
Committee 16—Economics of Railway Location and Operation		
Feasibility of Determining Track Maintenance Requirements by Digital Computer Analysis	$ 5,000	$ 5,000
Total	$ 5,000	$ 5,000
Committee 24—Cooperative Relations with Universities		
Student Research Grants	$ 1,000	$ 1,000
Total	$ 1,000	$ 1,000

---

* New projects, or reinstated projects similar or related in scope to previous projects.

	1965 Approved Budget	1964 Estimated Expenditure
Committee 30—Impact and Bridge Stresses		
Steel Bridges	$ 7,000	$ 7,000
Concrete Bridges	9,000	9,000
Determination of Longitudinal Forces in Bridges	......	7,500
Calculation of Bridge Stresses by Digital Computer	1,000	3,000
*Deflection and Depth Ratios of Bridges	2,500	......
Total	$ 19,500	$ 26,500
Committee 31—Continuous Welded Rail		
Butt-Welding of Rails	$ 12,000	$ 9,200
Total	$ 12,000	$ 9,200
Joint Committee on Relation Between Track and Equipment		
Relation of Wheel Load to Wheel Diameter	$ 8,500	$ 8,500
*Dynamic Action of Piggyback and New Types of Freight Cars	7,000	......
Effect of Heavy Drawbar Pull with Long Cars on Sharp Curves on Car and Track Stability	......	5,000
Relation of High Center of Gravity and Heavy Loading to Derailing and Roll Action Including Some of the High Capacity Cars of Recent Design	10,000	5,000
Effect of Slack Run-in on Lateral Forces Due to Jack Knifing of Locomotives and Long Cars	4,000	5,000
*Study to Determine the Best Locations for Hot Box Detectors	2,500	......
Total	$ 32,000	$ 23,500
Board Committee on Research		
Long-Range Weather Forecasting	$ 1,000	$ 1,000
*Methods of Rail Flaw Detection	20,000	......
Total	$ 21,000	$ 1,000
Electrical Laboratory and Instrumentation	$ 28,000	$ 27,000
Total	$ 28,000	$ 27,000
Detector Car Development and Leasing		
Further Development of Detector Car Testing—Road-Rail Units and Ultrasonic Units	$ 41,600	$ 41,600
Total	$ 41,600	$ 41,600
Technical Services		
General Technical Services	$ 18,300	$ 18,300
Total	$ 18,300	$ 18,300
Grand Total	$306,100	$286,100

---

* New projects, or reinstated projects similar or related in scope to previous projects.

FINANCES

Despite the anticipation of a deficit year for the Association in 1964, estimated at $6,447, due entirely to publishing the Third Edition of the Association's Recruiting Brochure and the necessity of reprinting a supply of the Portfolio of Trackwork Plans, the Association closed the year with total Disbursements exceeding Receipts by only $3,283.85—a very desirable and creditable showing, especially so in view of the unanticipated overexpenditure in the Pension item. This favorable situation is set forth in the accompanying Report of the Treasurer, Financial Statement, General Balance Sheet, and Statement of Cash Receipts and Disbursements for the calendar year 1964. Members should particularly note that while 1964 was a deficit year financially, the total assets of the Association were only $1,171 lower than in 1963.

Here is a comparison of Receipts and Disbursements for the past two years:

	1963	*1964*
Receipts	$73,653.48	$ 74,834.81
	66,159.99	78,118.66
	$ 7,496.49	$—3,283.85

The following reviews briefly the financial picture for the year. Receipts were some $1300 more than receipts in 1963, accountable solely by the fact that Convention Registration Fees were $1300 higher. All other items of receipts in 1964 closely approximated or slightly exceeded anticipated receipts, although the total actual receipts were $1,170 more than estimated receipts.

Disbursements, while $13,463 higher in 1964 than in 1963, were some $1900 under the total estimated budget for the year. This underexpenditure was due in most part to printshop economies realized in the reprinting of the Portfolio of Trackwork Plans, for which $6,500 had been budgeted, but only $4,750 expended, a saving of $1,750.

In addition, a saving of $1200 was realized in the postage category since anticipated raises in postal rates did not materialize during 1964. All other disbursement items closely approximated estimated expenditures for that year.

As a result of the factors enumerated above, the Association ended the year in a sound financial condition, which is expected to continue, but only through a continuing effort to hold the membership at least to its present level and by holding expenditures for special, non-remunerative activities and services within practical limits. In addition, the Association must continue, or extend if necessary, the policy of adequate "user charges" for all services rendered non-members or special services rendered individual members, groups of members or railroads.

LOOKING AHEAD

Accomplishmentwise, 1964 was an excellent year and will be hard to surpass. But, 1965 promises to exceed last year, not only from the point of view of committtee work and relations with colleges and universities and their engineering students but by showing an increase in membership and a balanced budget.

However, this prophecy will come true only through the dedication and earnest effort of not only the officers and directors, but the entire membership as well—Members, Associate Members and Junior Members. Each member may be assured that the hardest working of all will be the secretary and his staff and that they will leave no stone unturned to assure the continued forward progress and stability of the AREA, in all areas of endeavor.

COMPARISON OF RECEIPTS AND DISBURSEMENTS FOR THE LAST 20 YEARS

	Receipts	*Disbursements*	*Net Gain*
1945	32,305.00	29,305.00	3,000.00
1946	28,836.00	34,583.00	5,747.00*
1947	46,993.00	46,989.00	4.00
1948	57,741.00	53,062.00	4,679.00
1949	62,081.00	57,075.00	5,005.00
1950	59,752.00	51,795.00	7,957.00
1951	69,045.00	62,369.00	6,676.00
1952	77,514.00	76,964.00	550.00
1953	73,033.07	82,067.86	9,034.79*
1954	85,748.99	68,003.03	17,745.96*
1955	80,177.21	73,923.18	6,254.03
1956	79,531.11	70,336.17	9,014.04
1957	85,429.31	89,830.57	4,401.26*
1958	81,454.56	77,348.92	4,105.64
1959	80,407.16	80,297.48	109.68
1960	81,138.79	83,978.29	2,839.50*
1961	83,461.73	73,410.20	10,051.53
1962	76,097.28	87,344.12	11,246.84*
1963	73,653.48	66,156.99	7,496.49
1964	74,834.81	78,118.66	3,283.85*

---

*Deficit.

The 1966 Annual Convention will be held on March 14–16, in Chicago's Sherman House, a hotel that is no stranger to AREA members.

The following year, 1967, will see another American Railway Progress Exposition being staged at McCormick Place, Chicago. Again, it will be held in October, between the 8th and 14th. The Combined Railway Suppliers' Exhibit has reserved the huge lakeside exposition center in its entitrety and a General Committee for the 1967 Exposition has been organized, consisting of all railway and railway oriented organizations that participated in the 1963 affair, plus a number of others.

As in 1963, the AREA–AAR Engineering Division will hold two major meetings. One, the Business Meeting, will be held on March 9–10 at the Conrad Hilton Hotel and again will be a 1½-day, end-of-the-week, restricted-attendance affair. At this meeting, all of the official business of the Association will be transacted, thus keeping its committee activities on schedule.

The other meeting in 1967 will be a Membership Meeting held at McCormick Place during the first half of Exposition week. The official residence of members attending this meeting will be the LaSalle Hotel, located in the heart of the Loop at LaSalle and Madison Streets. Other than meetings of most of the Association's standing technical committees, the program will consist entirely of special features, as in October 1963.

Given the support and cooperation of all members, the American Railway Engineering Association can retain its place of eminence in the railroad industry and in the future even surpass its attainments of the past and present to make a greater contribution to railroading the world over.

Respectfully submitted.

EARL W. HODGKINS,
Executive Secretary.

Deceased Members

J. A. ANDERSON
Commissioner, State Highway Department, Lexington, Va.

J. E. ARMSTRONG
Retired Chief Engineer, Canadian Pacific Railway, Montreal, Que., Can.

R. C. BARDWELL
Retired Superintendent Water Supply, Chesapeake & Ohio Railway, Mount Dora, Fla.

F. E. BATES
Retired Vice President, Missouri Pacific Railroad, Creve Coeur Addition, St. Louis County, Mo.

SIDNEY BEACON
Retired Assistant Division Engineer, Missouri Pacific Lines, Palestine, Tex.

B. L. BEIER
Special Engineer, Erie Lackawanna Railroad, Cleveland, Ohio

C. H. BLACKMAN
Retired Chief Engineer, Louisville & Nashville Railroad, Louisville, Ky.

M. C. BLANCHARD
Retired Chief Engineer, Atchison, Topeka & Santa Fe Railway, Coast Lines, Los Angeles, Calif.

V. T. BOUGHTON
Consulting Editor, Engineering News-Record, Basking Ridge, N. J.

C. B. BRONSON
Retired Assistant Chief Engineer Maintenance of Way, New York Central System, Rhinebeck, N. Y.

H. F. BROWN
Retired District Engineer, Northern Pacific Railway, San Marino, Calif.

W. J. BURTON
Retired Assistant to Chief Engineer, Missouri Pacific Railroad, St. Louis, Mo.

H. B. BUSSING
Assistant to Chief Engineer, New York, New Haven & Hartford Railroad, Providence, R. I.

MAURICE COBURN
Retired Assistant Engineer, Pennsylvania Railroad, Indianapolis, Ind.

JAMES COLLINS
Atchison, Topeka & Santa Fe Railway, San Bernardino, Calif.

M. H. CORBYN
Engineer Public Works, Chicago, Rock Island & Pacific Railroad, Chicago, Ill.

W. N. DANIEL
Assistant Division Engineer, Loiuisville & Nashville Railroad, Nashville, Tenn.

F. H. DEMOYER
Valuation Engineer, Pennsylvania Railroad, Phialdelphia, Pa.

A. R. DEWEES
Retired Division Engineer, Pere Marquette Railway, Detroit, Mich.

C. J. FRESEMAN
Division Engineer, Chicago & North Western Railway, St. Paul, Minn.

L. E. GINGERICH
Retired Chief Mechanical Officer, Pennsylvania Railroad, Philadelphia, Pa.

E. A. HALE
1061 W. Rosemont Ave., Chicago, Ill.

E. A. HUMPHREYS
Retired Division Engineer, Cleveland, Cincinnati, Chicago & St. Louis Railway, Georgetown, Ky.

F. C. HUNTSMAN
Retired Office Engineer, Wabash Railroad, Macon, Mo.

S. R. HURSH
Retired Assistant Vice President, Pennsylvania Railroad, Bala-Cynwyd, Pa.

H. A. ISRAEL
Retired Superintendent, Missouri Pacific Railroad, Murphysboro, Ill.

C. H. JOHNSON
Assistant Engineer, Illinois Central Railroad, Chicago, Ill.

W. W. KELLY
Retired General Purchasing Agent, Atchison, Topeka & Santa Fe Railway, Dallas, Tex.

A. E. KING
Assistant Engineer, Missouri Pacific Railroad, St. Louis, Mo.

G. A. KIRLEY
Retired General Manager, Boston & Albany Railroad, Newtonville, Mass.

W. M. LUDOLPH
Retired Assistant Engineer, Chicago, Milwaukee, St. Paul & Pacific Railroad, Chicago, Ill.

T. C. MCCORD
Retired Division Engineer, Missouri Pacific Lines, Kingsville, Tex.

E. W. MCCUSKEY
Chief Engineer, Northeast Oklahoma Railroad, Miami, Okla.

R. K. MCKINNON
Assistant Chief Engineer, Central of Georgia Railroad, Savannah, Ga.

H. W. NEUEBAUMER
Division Engineer, Southern Pacific Company, San Francisco, Calif.

J. H. NUELLE
Retired President, Delaware & Hudson Railroad Corporation, Middletown, N. Y.

L. F. PARLETTE
Retired Assistant Chief Engineer, Philadelphia Transportation Company, Philadelphia, Pa.

J. W. POULTER
Chief Research Engineer, Koehring Company, Delafield, Wis.

T. VON SCHRENK
Consulting Engineer, St. Louis, Mo.

J. K. SIMMS
Retired Chief Engineer, United Fruit Company, West Newton, Mass.

W. D. SIMPSON
Retired Chief Engineer, Seaboard Air Line Railroad, Largo, Fla.

O. C. STEINMAYER
Retired Superintendent Timber Preservation, Canada Creosoting Company, Ltd., West Hartford, Conn.

R. A. VAN NESS
Retired Bridge Engineer System, Atchison, Topeka & Santa Fe Railway, Sebring, Fla.

W. B. VERCOE
Resident Engineer, Union Pacific Railroad, Omaha, Nebr.

J. G. WAITS
Assistant Chief Engineer, Duluth, Missabe & Iron Range Railroad, Duluth, Minn.

S. J. WATSON
Chief Draftsman, Chicago & North Western Railway, Chicago, Ill.

C. H. WIGGINS
Assistant Division Engineer, Seaboard Air Line Railroad, Miami, Fla.

W. W. WILDESON
Structural Draftsman, New York, Chicago & St. Louis Railroad, Cleveland, Ohio

G. S. WOODING
Division Engineer, New York Central System, Buffalo, N. Y.

A. B. ZABOROWSKI
Assistant Engineer, Chicago & North Western Railway, Milwaukee, Wis.

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1964

Balance on hand January 1, 1964			$153,229.32

RECEIPTS

Membership Account			
Entrance Fees	$ 1,670.00		
Dues	43,155.40	$ 44,825.40	
Sale of Publications			
Proceedings	$ 1,657.84		
Bulletins	1,635.97		
Manuals	9,273.50		
Track Plans	1,918.25		
Specifications	1,108.04		
Brochure	890.00	16,483.60	
Advertising			
Publications		5,869.77	
Interest Account			
Interest on Investments	$ 4,849.70		
Interest on Special Account	322.73	5,172.43	
Miscellaneous		2,483.61	
Total		74,834.81	

DISBURSEMENTS

Salaries	$27,530.70		
Bulletins and Proceedings	20,252.36		
Stationery and Printing	3,983.33		
Rent	1,140.00		
Postage	1,860.55		
Supplies	441.99		
Audit	400.00		
Pensions	1,902.70		
Social Security, Insurance, Etc.	1,477.73		
Manual	4,082.56		
Refunds	169.26		
Committee and Officers Expenses	385.90		
News Letter	2,059.85		
Annual Meeting	2,730.74		
Brochures	3,877.95		
Miscellaneous	1,070.71		
Track Plans	4,752.33		
Total		$ 78,118.66	
Excess of Disbursements over Receipts			3,283.85
Balance on hand December 31, 1964			$149,945.47

REPORT OF THE TREASURER

To the Members:

Balance on Hand, January 1, 1964		$153,229.32
Receipts during 1964	$ 74,834.81	
Paid out on Audited Vouchers	78,118.86	
Excess of Disbursements over Receipts		3,283.85
Balance on Hand December 31, 1964		
Consisting of:		
Bonds at cost	$149,211.48	
Cash in Northern Trust Company	—3,453.10 (Cr. Bal.)	
Special deposit in Northern Trust*	4,162.09	
Petty Cash	25.00	$149,945.47

---

*Including earned interest of $322.73.

We have make an examination of the accounts of the American Railway Engineering Association for the year ending December 31, 1964, and found them to be in accordance with the foregoing statement.

E. N. Thomas,
C. A. Bick,
Auditors.

GENERAL BALANCE SHEET

Assets:		*1964*	*1963*
Cash in Northern Trust Co.,			
Commercial Account—Credit Balance		$—3,453.10	$—1,846.52
Special Account	$ 3,839.36		
Interest on Special Account	322.73	4,162.09	5,839.36
Petty Cash		25.00	25.00
Due from Members		1,829.50	56.50
Due from Sale of Publications		49.22	36.00
Due from Advertising		159.80	924.80
Prepaid Postage		55.52	73.05
Furniture and Fixtures		1,000.00	1,000.00
Inventories:			
Publications (estimated)		500.00	500.00
Manuals		7,195.00	9,161.00
Track Plans		3,700.00	588.00
Binders, Indexes and Chapters		50.00	87.50
Investments (cost)		149,211.48	149,211.48
Interest Accrued on Investments		928.51	928.51
Totals		$165,413.02	$166,584.68
Liabilities:			
Members dues paid in advance		$ 305.25	$ 441.00
Surplus		165,107.77	166,143.68
Totals		$165,413.02	$166,584.68

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS YEAR 1964

		Commercial Account	*Special Account*
Cash in Bank, January 1, 1964 ... Cr. Bal.		$—1,846.52	$ 5,839.36
RECEIPTS:			
From members, sales of publications, interest, etc.	$74,834.81		
Transfer of funds		$—4,000.00	4,000.00
Interest on deposits		— 322.73	322.73
		$—6,169.25	$ 10,162.09
DISBURSEMENTS:			
Transfer of funds		6,000.00	—6,000.00
		$— 169.25	$ 4,162.09
Audited Vouchers	$78,118.66		
Excess of Disbursements over Receipts		$—3,283.85	
Cash in Bank December 31, 1964 ... Cr. Bal.		$—3,453.10	$ 4,162.09

American Railway Engineering Association

CONSTITUTION

Revised to July 10, 1962

Article I

Name, Object and Location

1. Name

The name of this Association shall be the AMERICAN RAILWAY ENGINEERING ASSOCIATION.

2. Object

The object of the Association shall be the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways.

3. Means to be Used

The means to be used for this purpose shall be:

(a) The investigation of matters pertaining to the object of the Association through Study and Research Committees.

(b) Meeting for the presentation and discussion of papers, and for action on the recommendations of committees.

(c) The publication of papers, reports and discussions.

4. Conclusions

The conclusions adopted by the Association shall be recommendatory.

5. Location

The office of the Association shall be located in Chicago, Ill.

Article II

Membership

1. Classes

The membership of this Association shall be divided into five classes: Members, Life Members, Honorary Members, Associates and Junior Members.

2. Qualifications

A. General

(a) An applicant to be eligible for membership in any class other than that of Junior Member shall be not less than 25 years of age.

(b) To be eligible for membership in any class, or for retention of membership as a Member, an Associate or a Junior Member, a person shall not be engaged directly or primarily in the sale to the railways of appliances, supplies, patents or patented services.

(c) The right to membership shall not be terminated by retirement from active service.

(d) In determining the eligibility for membership in any class, graduation in engineering from a school of recognized standing shall be considered as equivalent to three years of active practice, and satisfactory completion of each year of work in such school, without graduation, shall be considered as equivalent to one-half year of active practice.

(e) In determining the eligibility for Member under Section B (a) of this Article, each year of practical experience in engineering, or in science related thereof, prior to employment on a railway, if such experience were of the same specialized character as the current work of the applicant, shall be considered as equivalent to one year of railway service.

B. MEMBER

A Member shall be:

(a) An engineer or officer in the service of a railway corporation that is a common carrier, who has had not less than five years' experience in the location, construction, operation or maintenance of railways.

(b) A dean, professor, assistant professor, or equivalent in engineering in a university or college of recognized standing, or an instructor or equivalent in such university or college, who, with an engineering degree, has had at least two years' experience in teaching engineering.

(c) An engineer or member of a public board, commission or other official agency who, in the discharge of his regular duties, deals with railway problems.

(d) An editor of a trade or technical magazine who, in the discharge of his regular duties, deals with railway problems, and who has had the equivalent of five years' engineering or railway experience.

(e) A consulting engineer, engaged in private practice, or an engineer in his employ or in the employ of a consulting engineering organization, who has had the equivalent of five years' engineering experience.

C. LIFE MEMBER

A Life Member shall be a Member or an Associate who has paid dues for 35 years, or who has been retired under a recognized retirement plan and has paid dues for not less than 25 years.

D. HONORARY MEMBER

(a) An Honorary Member shall be a person of acknowledged eminence in railways engineering or management.

(b) The number of Honorary Members shall be limited to ten.

E. ASSOCIATE

An Associate shall be:

(a) An engineer of a railway which is essentially an adjunct of an industry, or which is used primarily to transport the products and materials of an industry to and from a railway which is a common carrier.

(b) A person qualified by training and experience to cooperate with Members in the object of this Association, but who is not qualified to become a Member.

F. JUNIOR MEMBER

(a) A Junior Member shall be not less than 21 years of age and shall be an engineering employee of a railway corporation who has had not less than three years of experience in the location, construction, operation or maintenance of railways.

(b) His membership in this classification in the Association shall terminate at the end of the calendar year in which he becomes 30 years of age.

(c) He may make application for membership other than as a Junior Member at any time when he becomes eligible to do so.

3. Transfers

The Board of Direction shall transfer from one class of membership to another, or may remove from membership, any person whose qualifications so change as to warrant such action.

4. Rights

(a) Members, and Life Members who were formerly Members, shall have all the rights and privileges of the Association. Life Members who were formerly Associates shall continue to have all the rights and privileges of Associates.

(b) Honorary Members shall have all the rights and privileges of the Association except those of holding elective office, provided, however, that Members or Life Members who are elected Honorary Members shall retain all the rights and privileges of the Association.

(c) Associates and Junior Members shall have all the rights and privileges of the Association except those of voting and holding elective office.

Article III

Admission, Resignation, Expulsion and Reinstatement

1. Charter Membership

The Charter Membership of this Association consists of all persons elected to membership before March 15, 1900.

2. Application for Membership

(a) A person desirous of membership in this Association shall make application upon the form provided by the Board of Direction. In the event that Junior Membership is desired, the applicant shall so state.

(b) The applicant shall give the names of at least three Members of this Association to whom personally known. Each of these Members shall be requested by the Executive Secretary of the Association to certify to a personal knowledge of the applicant with an opinion of the applicant's qualifications for membership.

(c) If an applicant is not personally known to as many as three Members of this Association, the names of well-known persons engaged in railway or allied professional work to whom he is personally known shall be substituted, as necessary, to provide a total of at least three references. Each of these persons shall be requested by the Executive Secretary of the Association to certify to a personal knowledge of the applicant, with an opinion of the applicant's qualifications for membership.

(d) No further action shall be taken upon the application until replies have been received from at least three of the persons named by the applicant as references.

3. Election to Membership

(a) Upon completion of the application in accordance with Section 2 of this Article the Board of Direction through its Membership Committee shall consider the application and make such investigation as it may consider desirable or necessary.

(b) Upon completion of such consideration and investigation, each member of the Board of Direction shall be supplied with the required information, together with the recommendation of the Membership Committee as to the class of membership, if any, to which the applicant is eligible, and the admission of the applicant shall be canvassed by ballot among the members of the Board of Direction.

(c) In the event that an application has been made under the provisions of Section 2, Paragraphs (a) and (b) of this Article, a two-thirds affirmative vote of the entire Board of Direction shall be required for election.

(d) In the event that an application has been made under the provision of Section 2, Paragraphs (a) and (c) of the Article, a unanimous affirmative vote of the entire Board of Direction shall be required for election.

4. Subscription to the Constitution

An applicant for any class of membership in this Association shall declare his willingness to abide by the Constitution of the Association in his application for membership.

5. Honorary Member

A proposal for Honorary Membership shall be endorsed by ten or more Members of the Association and a copy furnished each member of the Board of Direction. The nominee shall be declared an Honorary Member upon receiving a unanimous vote of the entire Board of Direction.

6. Resignation

The Board of Direction shall accept the resignation, tendered in writing, of any person holding membership in the Association whose obligations to the Association have been fulfilled.

7. Expulsion

Charges of misconduct on the part of anyone holding membership in this Association, if in writing and signed by ten or more Members, may be submitted to the Board of Direction for examination and action. If, in the opinion of the Board action is warranted, the person complained of shall be served with a copy of such charges and shall be given an opportunity to answer them to the Board of Direction. After such opportunity has been given, the Board of Direction shall take final action. A two-thirds affirmative vote of the entire Board of Direction shall be required for expulsion.

8. Reinstatement

(a) A person having been a Member, an Associate or a Junior Member of this Association and having resigned such membership while in good standing may be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

(b) A person having been a Member, an Associate or a Junior Member of this Association and having forfeited membership under the provisions of Article IV, Section 3, may, upon such conditions as may be fixed by the Board, be reinstated by a two-thirds affirmative vote of the entire Board of Direction.

ARTICLE IV

DUES

1. Entrance Fee

(a) An entrance fee of $10 shall be payable to the Association with each application for membership other than Junior Membership. This sum shall be returned to an applicant not elected.

(b) No entrance fee shall be required for Junior Membership, except that a Junior Member, in transferring to another class of membership, shall pay the entrance fee prescribed for other classes of Membership.

2. Annual Dues

(a) The annual dues for each Member and each Associate shall be $15.

(b) The annual dues for each Junior Member shall be $5.

(c) Life Members and Honorary Members shall be exempt from the payment of dues. Life Members desiring to continue to receive the Bulletins and Proceedings of the Association may do so by paying a subscription fee prescribed by the Board of Direction

3. Arrears

A person whose dues are not paid before April 1 of the current year shall be notified by the Executive Secretary. If the dues are still unpaid on July 1, further notice shall be given, informing the person that he is not in good standing in the Association. If the dues remain unpaid by October 1, the person shall be notified that he will no longer receive the publications of the Association. If the dues are not paid by December 31, the person shall forfeit membership without further action or notice, except as provided for in Section 4 of this Article.

4. Remission of Dues

The Board of Direction may extend the time of payment of dues, and may remit the dues of any Member, Associate or Junior Member who, for good reason, is unable to pay them.

Article V

OFFICERS

1. Officers

(a) The officers of the Association shall be a President, two Vice Presidents, twelve Directors, an Executive Secretary and a Treasurer.

(b) The President, the Vice Presidents and the Directors, together with the two latest living Past Presidents continuing to be Members, shall constitute the Board of Direction, in which the government of the Association shall be vested; they shall act as the trustees and have the custody of all property belonging to the Association. The President, the Vice Presidents and the Directors shall be Members.

(c) The Executive Secretary and the Treasurer shall be appointed by the Board of Direction.

2. Term of Office

The term of office of the President shall be one year, of the Vice Presidents two years and of the Directors three years. The term of each shall begin at the close of the annual convention at which elected and continue until a successor is qualified. All other officers and employees shall hold office or position at the pleasure of the Board of Direction.

3. Officers Elected Annually

(a) There shall be elected at each annual convention a President, one Vice President and four Directors.

(b) The candidates for President and for Vice President shall be selected from the members or past members of the Board of Direction.

4. Conditions of Re-election of Officers

A President shall be ineligible for re-election, except as provided for in Section 5 (e) of this Article. Vice Presidents and Directors shall be ineligible for re-election to the same office, except as provided for in Section 5 (e) of this Article, until, at least one full term has elapsed after the end of their respective terms.

5. Vacancies in Offices

(a) If a vacancy should occur in the office of President, as set forth in Section 6 of this Article, the senior Vice President shall immediately and automatically become President for the unexpired term.

(b) If a vacancy should occur in the office of the senior Vice President, due to advancement under Section 5 (a) of this Article, or for reasons set forth in Section 6 of this Article, the junior Vice President shall automatically become senior Vice President for the unexpired term.

(c) If a vacancy should occur in the office of the junior Vice President, due to advancement under Section 5 (b) of this Article, or for reasons set forth in Section 6 of this Article, the Board of Direction shall by the affirmative vote of two-thirds of its entire membership, select a junior Vice President from the members or past members of the Board of Direction.

(d) A vacancy in the office of Director, due to advancement of a Director to junior Vice President under Section 5 (c) of this Article, or for reasons set forth in Section 6 of this Article, shall be filled by the Board of Direction by the affirmative vote of two-thirds of its entire membership.

(e) An incumbent in any office for an unexpired term shall be eligible for re-election to the office held; provided, however, that anyone selected to fill a vacancy as Director shall be eligible for election to that office, excepting that such appointee filling out an unexpired term of two years or more shall be considered as coming within the provisions of Section 4 of this Article.

6. Vacation of Office

(a) In the event of the death of an elected officer, or his resignation from office, or if he should cease to be a Member of the Association as provided in Section 2 (B), Article II; Section 6 or 7, Article III; or Section 3, Article IV, the office shall be considered as vacated.

(b) In the event of the disability of an officer or neglect in the performance of duty by an officer, the Board of Direction, by the affirmative vote of two-thirds of its entire membership shall have the power to declare the office vacant.

Article VI

NOMINATION AND ELECTION OF OFFICERS

1. Nominating Committee

(a) There shall be a Nominating Committee composed of the five latest living Past Presidents of the Association, who are Members, and five Members who are not officers.

(b) The five Members who are not Past Presidents shall be elected annually for a term of one year, when the officers of the Association are elected.

(c) The senior Past President who is a member of the committee shall be the chairman of the committee. In the absence of the senior Past President from a meeting of the committee the Past President next in seniority present shall act as chairman.

2. Method of Nominating

(a) At least three months prior to the annual convention, the Chairman shall call a meeting of the committee at a convenient place, at which nominees for the several elective offices shall be selected as follows:

Office to be Filled	*Number of Candidates to be named by the Nominating Committee*	*Number of Candidates to be elected at the Annual Election of Officers*
President	1	1
Vice President	1	1
Directors	8	4
Nominating Committee	10	5

(b) The Chairman of the Nominating Committee shall send the names of the nominees to the President and Executive Secretary within 15 days after the meeting of the Nominating Committee, and the Executive Secretary shall report the names of these nominees to the members of the Association not less than 60 days prior to the annual convention.

(c) At any time prior to 30 days before the annual convention, any ten or more Members may send to the Executive Secretary additional nominations for any elective office for the ensuing year, signed by such Members.

(d) If any person nominated shall be found by the Board of Direction to be ineligible for the office for which nominated, or should a nominee decline such nomination, his name shall be withdrawn. The Board of Direction may fill any vacancies that may occur in the list of nominees up to the time the ballots are sent out.

3. Ballots Issued

Not less than thirty days prior to each annual convention, the Executive Secretary shall issue a ballot to each voting Member of record who has paid his dues to or beyond December 31 of the previous year, listing the several candidates to be voted upon. When there is more than one candidate for any office, the names shall be arranged on the ballot in the order that shall be determined by lot by the Nominating Committee. The ballot shall be accompanied by a statement giving for each candidate his record of membership and activities in this Association.

4. Substitution of Names

Members may remove names from the printed ballot list and may substitute the name or names of any other person or persons eligible for any office, but the number of names voted for each office on the ballot must not exceed the number to be elected at that time to such office.

5. Ballots

(a) Ballots shall be placed in an envelope, sealed and endorsed with the name of the voter, and mailed to or deposited with the Executive Secretary at any time previous to the closure of the polls.

(b) A voter may withdraw his ballot, and cast another, at any time before the polls close.

(c) Ballots received in unendorsed envelopes, or from persons not qualified to vote, shall not be counted.

(d) The ballots and envelopes shall be preserved for not less than ten days after the vote is canvassed.

6. Closure of Polls

The polls shall be closed at 12 o'clock noon on the first day of the annual convention, and the ballots shall be counted by tellers appointed by the presiding officer.

7. Election

(a) The persons who shall receive the highest number of votes for the offices for which they are candidates shall be declared elected.

(b) In case of a tie between two or more candidates for the same office, the Members present at the annual convention shall elect the officer by ballot from the candidates so tied.

(c) The presiding officer shall announce at the convention the names of the officers elected in accordance with this Article.

Article VII

MANAGEMENT

1. President

The President shall have general supervision of the affairs of the Association, shall preside at meetings of the Association and of the Board of Direction, and, by virtue of his office, shall be a member of all committees, except the Nominating Committee.

2. Vice Presidents

The Vice Presidents, in order of seniority, shall preside at meetings in the absence of the President.

3. Treasurer

The Treasurer shall pay all bills of the Association when properly certified by the Executive Secretary and approved by the Finance Committee. He shall make an annual report as to the financial condition of the Association and such other reports as may be called for by the Board of Direction.

4. Executive Secretary

The Executive Secretary, under the direction of the President and Board of Direction shall be the Executive Officer of the Association and shall attend the meetings of the Association and of the Board of Direction, prepare the business therefor, and record the proceedings thereof. The Executive Secretary shall see that all money due the Association is collected, is credited to the proper accounts, and is deposited in the designated depository of the Association, with receipt to the Treasurer therefor. He shall personally certify to the accuracy of all bills and vouchers on which money is to be paid. He shall invest all funds of the Association not needed for current disbursements, as shall be recommended by the Finance Committee and approved by the Board of Direction, with notification to the Treasurer of such investments. The Executive Secretary shall conduct the correspondence of the Association, make an annual report to the Association, and perform such other duties as the Board of Direction may prescribe.

5. Auditing of Accounts

The financial accounts of the Association shall be audited annually by an accountant or accountants approved by and under the direction of the Finance Committee.

6. Board of Direction and Executive Committee

(a) The Board of Direction shall manage the affairs of the Association, and shall have full power to control and regulate all matters not otherwise provided for in the Constitution.

(b) The Board of Direction shall meet within thirty days after each annual convention, and at such other times as the President may direct. Special meetings shall be called on request, in writing, of five members of the Board of Direction.

(c) Seven members of the Board of Direction shall constitute a quorum.

(d) At the first meeting of the Board of Direction after the annual convention, the President shall appoint from the membership of the Board, subject to ratification by the Board, four members to serve with him as an Executive Committee which shall possess and may exercise during intervals between meetings of the Board, all of the powers of the Board on matters which in the judgment of a majority of the Executive Committee cannot properly be delayed until the next meeting of the Board. Actions of the Executive Committee shall be reported to the Board of Direction at the next meeting of the Board. The President shall be chairman of the Executive Committee. Actions of the Executive Committee shall be authorized by a concurring majority of its full membership. Members of the Executive Committee shall serve until their successors are appointed or until the Executive Committee is dissolved by action of a majority of the full membership of the Board of Direction. Following dissolution of the Executive Committee it may be re-created at any time by action of a majority of the full membership of the Board of Direction. If not so re-created prior to the next annual convention, the Executive Committee shall be reconstituted in the normal manner at the first meeting of the Board of Direction following the convention.

7. Administrative Committees

At the first meeting of the Board of Direction after the annual convention, the following Administrative Committees, each consisting of not less than three members, shall be appointed by the President. The personnel of these committees shall be subject to approval by the Board of Direction.

Assignments
Finance
Manual
Membership
Personnel
Publications
Research

Other special Administrative Committees may be appointed by the President at any time, and reappointed annually, if necessary, their personnel being subject to approval by the Board of Direction.

Membership on Administrative Committees shall be restricted to members of the Board of Direction, except that one or two members of the Administrative Committee on Research may be past members of the Board of Direction.

8. Study and Research Committees

The Board of Direction may establish continuing or special Study and Research Committees to investigate, consider, and report upon subjects appropriate to the object of the Association, as set forth in Art. I.

9. Duties of Administrative Committees

(a) Assignments

The Assignments Committee shall review and pass upon the recommendations of Association Study and Research Committees for subjects to be investigated, considered and reported on by these committees during the ensuing Association year, and shall report thereon to the Board of Direction for its approval. The Assignments Committee shall have authority to assign additional subjects or change the scope of any existing subjects at any time during the year, reporting its action thereon to the Board at its next regular meeting.

(b) Finance

The Finance Committee shall have immediate supervision of the accounts and financial affairs of the Association; shall approve all bills before payment, and shall make recommendations to the Board of Direction as to the investment of funds and other financial matters. The Finance Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money other than the amounts necessary to meet ordinary current expenses of the Association, except by authority of the Board of Direction.

(c) Manual

The Manual Committee, with the assistance of the Publications Committee, shall have general supervision over the Manual.

(d) Membership

The Membership Committee shall investigate applicants for membership and shall make recommendations to the Board of Direction with reference thereto.

(e) Personnel

The Personnel Committee shall review and pass upon applications of members for appointment to Study and Research Committees, and shall also appoint the chairman and vice chairman of such committees and make a report thereon to the Board of Direction for its approval. Should an unexpected vacancy in chairmanship or vice chairmanship of any such committee occur, the Personnel Committee shall have authority to fill such vacancy immediately, reporting its action thereon to the Board at its next regular meeting.

(f) Publications

The Publications Committee shall have general supervision over the publications of the Association. The Publications Committee shall not have the power to incur debts or other obligations binding the Association, nor authorize the payment of money except by authority of the Board of Direction.

(g) Research

The Research Committee shall encourage and coordinate the research activities of the Association, in the course of accomplishment of which it shall review and pass upon the recommendations of Study and Research Committees for research projects and shall report thereon to the Board of Direction, recommending for approval specific projects initiated by these committees or by the Research Committee and recommending allotments of funds for these projects in the research budget of the Association of American Railroads or from other sources compatible therewith; shall collaborate closely with the research staff of the Association of American Railroads; and when called upon by the Vice President—Research or the Vice President—Operations and Maintenance of that association, members of the Research Committee shall engage in the activities of advisory committees or groups of that organization and shall report from time to time to the Board of Direction on those activities.

10. Special Committees

The Board of Direction may appoint special committees to examine into and report upon any subject connected with the objects of this Association.

11. Discussion by Non-Members

The Board of Direction may invite discussions of reports from persons not members of the Association.

12. Sanction of Act of Board of Direction

An act of the Board of Direction which shall have received the expressed or implied sanction of the membership at the next annual convention of the Association shall be deemed to be the act of the Association.

Article VIII

MEETINGS

1. Annual Convention

(a) The Annual Convention of the Association shall be held in the City of Chicago, Ill., or in such other city as may be determined by the affirmative vote of two-thirds of the entire membership of the Board of Direction. The convention in any year shall be held on dates determined by the affirmative vote of two-thirds of the entire membership of the Board of Direction.

(b) The Executive Secretary shall notify all members of the Association of the time and place of the annual convention at least 30 days in advance thereof.

(c) The order of business at the annual convention of the Association shall be:

Reading of the minutes of the last meeting
Address of the President
Reports of the Executive Secretary and the Treasurer
Reports of committees
Unfinished business
New business
Installation of officers
Adjournment

(d) This order of business may be changed by a majority vote of Members present.

(e) The proceedings shall be governed by "Robert's Rules of Order" except as otherwise herein provided.

(f) Discussions shall be limited to Members and to those others invited by the presiding officer to speak.

2. Special Meetings

Special meetings of the Associations may be called by the Board of Directions on its own initiative, and may be so called by the Board of Direction upon written request of 100 Members. The request shall state the purpose of such meeting.

The call for such special meeting shall be issued not less than ten days in advance of the proposed date of such meeting and shall state the purpose and place of the meeting. No other business shall be taken up at such meeting.

3. Quorum

Twenty-five Members shall constitute a quorum at all meetings of the Association.

Article IX

AMENDMENT

1. Amendment

Proposed amendment of this Constitution shall be made in writing, shall be signed by not less than ten Members, and shall be acted upon in the following manner:

The amendment shall be presented to the Executive Secretary, who shall send a copy to each member of the Board of Direction as soon as received. If a majority of the entire Board of Direction so votes, the matter shall be submitted to the Association by letter ballot.

Sixty days after the date of issue of the letter ballot, the Board of Direction shall canvass the ballots which have been received, and if two-thirds of such ballots are in the affirmative the amendment shall be declared adopted and shall become effective immediately. The result of the letter ballot shall be announced to members of the Association.

INDEX OF PROCEEDINGS, Vol. 66, 1965

A

Accounting, ICC classifications, revisions and interpretations, 242, 606
Agreement form, disposal of major surplus railway facilities, 158, 646
  —petroleum and other liquified gases, railway property used for unloading and storing, lease, 161, 646
—reimbursement for preliminary engineering expenses, 164, 646
—weed-control chemicals on railway property, purchase and application of, 154 645
Alaska Railroad, 1964 earthquake damages to, address, I. P. Cook, 750
Annual luncheon, 703
Annual Meeting, closing session, 775
—opening session, 587
—program, 583
Armstrong, J. E., memoir, 781
Asphalt treated ballast, 569, 749
ASTM specifications designations, masonry, 322, 663
Atchison, Topeka & Santa Fe, ballast, asphalt treated, 569, 749
—joint bar service test, 470, 756
—soil stabilization by chemicals, 549, 747

B

Ballast, asphalt treated, and bridge decks, 569, 749
—sections, revisions approved, 569, 749
Baltimore & Ohio, analysis of maintenance of way work, 259, 614
Bank protection, use of soil-cement construction, 532, 746
Bardwell, Robert Cousins, memoir, 100
Batteries, water for use in, specifications, 126, 634
Beams, prestressed concrete, single and double box, 317, 662
Berg, A. B., investigations of disturbed track conditions at Mesa, Wash., 551, 747
Bessemer & Lake Erie, rail, laid tight, service test, 500, 761
Bibliographies, (See Engineering and Valuation Records)
—(See Waterways and Harbors)
Birch, L. W., developments in the field of railway electrification, 429, 649
Blackman, C. H., memoir, 710
Box beams, prestressed concrete, laboratory investigation, 317, 662
Bridge frames, stress distribution in, 296, 653
Bridges, concrete, rules for rating existing, 307, 662
—deck plates, corrosion of, 295, 653
—glued-laminated, performance and durability, address, F. P. Drew, 677
—rating rules for, revisions, 294, 653
—steel, fixed spans, specifications, revisions, 292, 293, 653
  —movable spans, specifications, revisions, 293, 653
—welded, railroad, address, J. E. South, 655
—wood, design specifications, revisions, 300, 674
Buildings, report and discussion, 187, 719
—railway, infra-red heating of, 222, 720
  —paint and coating products, new advances in, 199, 720
  —plastic materials, use of in, 210, 720
  —portable, station, 192, 719
  —prestressed concrete for, 202, 720
  —synthetic resins for adhesives, use of in, 195, 719
Burris, T. F., president's address, 589

C

Coburn, Maurice, memoir, 306
Code, C. J., panel discussion on standardization, 764
College and university staff members, stimulate greater interest in current railroad problems and practices, including AREA membership, 333, 695
College and university students, careers in railroading, presenting positive approach to, 328, 694
—cooperative system of education, 330, 695
—importance of bringing into railroad service, 327, 694
—railway cooperation and contributing to activities of, 328, 694
—recruiting and retaining in railroad service, 327, 694
—stimulate greater interest among in science of transportation, 328, 694
—summer employment of, 330, 695
—topics suggested for theses on railroad subjects, cash grants available, 333, 695
Computers, electronic, man-machine communication, by Prof. C. L. Miller, 1
  —new developments in engineering use of, address, Prof. C. L. Miller, 714
  —potential application to railway engineering problems, 148, 711
  —use of for railway bridge problems, 184, 672
Concrete, prestressed, box beams, laboratory investigation of, 317, 662
  —railway buildings, 202, 720
  —structures, specifications, revisions, 316, 662
  —trestles, using box beams, specifications, revisions, 316, 662
Concrete, repair and restoration, use of epoxy compounds, 311, 662
Construction reports, data processing of, 234, 605
Continuous Welded Rail, report and discussion, 507, 757
—economics, 519, 759
—fabrication, development of specifications for, 508, 758
—failures, butt-welded joints, service and detected, 509, 758
—fastenings, 518, 758
—laboratory investigation, AAR, rolling-load and slow-bend tests, 514, 758

—laid, by years, 517, 758
—laying, development of recommended practices for, 517, 578
  —dual, on the B&O, 259, 614
  —economics of labor in, 269, 614
—maintenance, 518, 758
—welding secondhand rail, 519, 759
Contract Forms, report and discussion, 153, 645
Cook, I. P., address, 1964 earthquake damages to the Alaska Railroad, 750
Cooperative Relations with Universities, report and discussion, 325, 647
Corrosion, deck plates, 73, 295, 653
—hot water heating systems, control of, 105, 632
—underground metallic structures, 354, 648
Courts and regulatory bodies, current developments in valuation and depreciation, 240, 606
Critical path method for railway engineering, address, F. J. Raskopf, Jr., 721
Crossings, highway–railway grade, advance warning, additional, to traffic approaching, 96, 638
  —automatic protection, alternate types, 96, 638
  —prefabricated, merits and economics of, 93, 636
  —protection, merits of various types, 93, 636
  —signals, recommended use of, 92, 635
    —specifications, revisions, 92, 635
  —signs, recommended use of, revisions, 90, 635
  —stop signs, highway type, use and effectiveness of, 94, 637
Crossings, simulated, service test, 503, 761
Curves, critical review of speed on, 501, 761
Canadian National, replacement of Messiter tunnel by a through cut, 559, 748
Cathodic protection, pipelines and steel storage tanks, 108, 633
Charles, J. L., construction of Great Slave Lake Railway, 31
Chemical control of vegetation, 576, 749
Chesapeake & Ohio, rail, service test, 479, 757
Chicago & North Western, joint bar service test, 470, 756
—treated ballast test, 572, 749
Chicago, Milwaukee, St. Paul & Pacific, crossings, simulated, service test, 503, 761
Chicago, Rock Island & Pacific, asphalt treated bridge decks, 574, 749
Clearance diagrams, equipment, limited interchange, 249, 611
—maximum width of cars with various truck centers, 248, 250, 611
—outline for single loads, without end overhand, open-top cars, 251, 611
—unrestricted interchange, 247, 611
Clearance information, published, review present methods of presenting, 252, 612
Clearance records, suggested method of charting all obstructions, 255, 612
Clearances, report and discussion, 245, 611
—published, suggested method of presenting, 252, 612
Constitution, 807

D

Data processing, construction reports, engineering phases, 234, 605
Deck plates, corrosion of, 73, 295, 653
Depreciation and valuation, current developments in connection with regulatory bodies and courts, 240, 606
DeVine, G. S., annual luncheon address, the challenge of change, 704
Diesel fueling and unloading stations, methods of controlling spillage, 125, 634
Diesel locomotives, fuel and water service, revisions, 102, 631
Drew, F. P., address, performance and durability of glued-laminated railway bridges, 677

E

Economics, labor, laying CWR, 269, 614
  —tie renewals, cutting versus removing whole, 270, 615
Economics of railway engineering projects designed to improve quality of transportation service, 145, 711
Economics of Railway Labor, report and discussion, 257, 613
Economics of Railway Location and Operation, report and discussion, 143, 710
Electric heating, 427, 649
Electrical Manual, AAR, revisions, Section 18, Wiring Diagrams, 340, 647
  —Section 10, Wire, Cable and Insulating Materials, 355, 648
Electricity, report and discussion, 339, 647
Electronic track scales, manufacture and installation, 129, 618
Embankment, effect of irrigation system on, 550, 747
Engineering and Valuation Records, report and discussion, 231, 604
—bibliography, 232, 605
Enstrom, W. A., greetings from NRAA, 596
Epoxy compounds, use of in repair and restoration of concrete, 311, 662
Epoxy resin, coatings on steel and concrete, 59
Epoxy shear keys, laboratory investigation, 321, 662
Erie–Lackawanna, rail, laid tight, service test, 500, 761
Expansive cements and concretes, by Shu-t'ien Li, 177, 616
Everitt, Dean W. L., address, what price glamour, 697

F

Forest products, service records, 229, 609
Foundations and earth pressures, advance report, 311, 662
Fuel oil, diesel fueling and unloading stations, methods of controlling spillage, 125, 634

G

Galvanic corrosion, underground metallic structures, 354, 648
Gates, automatic, crossing, specifications, revisions, 92, 635
Geologic study in area adjacent to disturbed track at Mesa, Wash., 551, 747
Grade-crossing collisions, prevention of, address, Joseph H. Hays, 639
Grade crossings, (See Crossings, highway-railway grade)
Great Northern, rail, service test, 480, 757
Great Slave Lake Railway, construction of, by J. L. Charles, 31

H

Hays, Joseph H., address, ICC report on prevention of grade-crossing collisions, 639
Heating, electric, 427, 649
—infra-red, 222, 720
Heating systems, hot water, corrosion control in, 105, 632
Helicopter spraying on right-of-way, 576, 749
Henderson, R. L., address, lighting is not a luxury, 651
Highways, report and discussion, 89, 635
Hillman, A. B., report and statement of treasurer, 595, 805
Hodgkins, E. W., executive secretary's statement and report, 591, 785
Hot water heating systems, corrosion control in, 105, 632
Hursh, Samuel R., memoir, 326

I

ICC, accounting classifications, changes on, 242, 606
—bureau of valuation, current developments, 240, 606
Illumination, lighting maintenance, 343, 648
—piggyback yards, 345, 648
Illinois Central Rail cropping, wet abrasive wheel method, 471, 757
Impact and Bridge Stresses, report and discussion, 183, 671
Impact, bridge, test on AT&SF, 185, 672
  —test on SAL, 184, 672
  —test on Western Pacific, 185, 672
—computers, electronic, use of for railway bridge problems, 184, 672
—concrete bridge slabs, 185, 672
—live load in bridge floors, distribution, 183, 671
Industrial engineering, study of freight car repair facility, by G. S. Sowers, 49
Infra-red heating, for buildings, 222, 720
Iron and Steel Structures, report and discussion, 291, 653

J

Johnson, Albert Willard, memoir, 101
Joint bars, service test, 470, 756
—AT&SF, 470, 756
—C&NW, 470, 756

K

Keim, J. W., investigations of disturbed track condition at Mesa, Wash., 551, 747

L

Labor, economics of in tie removals, 270, 615
—economics of laying continuous welded rail, 269, 614
Laminated stringers, laboratory investigation of, 302, 675
Li, Shu-t'ien, expensive cements and concretes, 177, 616
Lighting is not a luxury, address, R. L. Henderson, 651
Lighting, maintenance of, 345, 648
—piggyback yards, 345, 648
Louisville & Nashville, rail, laid tight, service test, 500, 761
Luncheon, annual, 703

M

Maintenance of way expense, various traffic volumes, effect of using variations, in terms of equated mileage or other derived factors, for allocation of available funds to maintenance of way, 147, 711
Maintenance of way work, analysis of operations, Baltimore & Ohio, 259, 614
Maintenance of Way Work Equipment, report and discussion, 273, 742
—reports and records, reapproved, 274, 743
Manion, R. R., address, where do we go from here, 597
Masonry, report and discussion, 305, 661
Masonry structures, deterioration and repair, 311, 662
Miles, R. D., through cut to replace Messiter tunnel on the CNR, 559, 748
Miller, Prof. C. L., address, new developments in engineering use of computers, 714
Miller, Prof. C. L., man-machine communication in civil engineering, 1
Monon, treated ballast test, 572, 749
Moon-port structures take shape at Cape Kennedy, address, Dr. Anton Tedesko, 663

N

Nominating committee, 585
Norfolk & Western, rail, service test, 483, 757
—treated asphalt test, 571, 749
Northern Pacific, effect of irrigation system on railroad embankment, 550, 747
—investigation of disturbed track condition at Mesa, Wash., 551, 747

P

Paint and coating products, railway buildings, new advances in, 199, 720
Painting and preparation of steel surfaces, 296, 653
Panel discussion on standardization, 764
Passenger stations (See Stations, passenger)
Pennsylvania, rail, service test, 482, 757
Petroleum gas, liquified, installation and maintenance of facilities for, 115, 634
Pipelines, cathodic protection of, 108, 633
—flammable and non-flammable materials, progress report, 536, 746
Pittsburgh & West Virginia, asphalt treated bridge decks, 573, 749
Plastic materials, use of in railway buildings, 210, 720
Preservative treatment, in-place, of timber trestles, 304, 676
President's address, 589
Prestressed concrete, (See Concrete, prestressed)

R

Rail, report and discussion, 445, 756
—continuous welded (See Continuous welded rail)
—control-cooled, failure statistics, 447, 756
—control-cooled, performance, failures, 454, 756
—cropping, wet abrasive wheel method, 471, 757
—failure statistics, 454, 756
—laying tight, with frozen joints, service tests, 500, 761
—sections, standardization of, 493, 757
—service tests, 479, 757
—78-ft, service and economics, 494, 757
—shelly spots and head checks, method of prevention, service tests, AAR, 479, 757
—shelly, studies at AAR Research Center, 484, 757
Rail-water transfer facilities, planning, construction and maintenance, 171, 616
Railway electrification, developments in the field of, 429, 649
Raskopf, F. J., Jr., address, critical path method for railway engineering, 721
Rating rules, existing concrete bridges, 307, 662
Reebie, Robert A., address, engineering efficient transfer terminals, the keystone of successful rail-highway transportation, 623
Regulatory bodies and courts, current developments in valuation and depreciation, 240, 606
Reflex units, switch lamps and targets, 504, 761
Resins and adhesives, synthetic, application to wood bridges and trestles, 301, 675
Resins, synthetic, for adhesives in railway buildings, 195, 719
Roadbed, across reservoir areas, construction and protection, specifications, revisions, 523, 746
—stabilization, 547, 747
Roadway, formation of, tentative specifications, 537, 747
Roadway and Ballast, report and discussion, 521, 745

S

Salmon, J. M., Jr., panel discussion on standardization, 764
Sanitary and servicing facilities, railroad, design, construction and operation, relations with governmental agencies pertaining to, 107, 633
Scales, automatic weight-indicating and recording devices, 137, 618
—track, electronic, manufacture and installation, 129, 618
Secretary, executive, statement and report, 591, 785
Service test records, forest products, 229, 609
Shear keys, epoxy, laboratory investigation, 321, 662
Shelly rail (See Rail, shelly)
Shop, for manufacture of roadway signs, layout of, 567, 748
Short, F. E., memoir, 743
Signals, highway-railway grade crossing, (See Crossings, highway-railway grade)
Signs, highway crossing (See Crossings, highway-railway grade)
—passenger stations, location and design of, deleted, 191, 719
—roadway, shop layout for production of, 566, 748
Simpson, William Dudley, memoir, 446
Sinkoff, M. D., address, bringing the computer to all engineers, 148, 711
Snow removal equipment, 284, 744
Soil-cement construction for bank protection on levees and embankments, 532, 746
Soil stabilization by chemicals, 547, 747
South, J. E., address, welded railroad bridges, 655
Sowers, George S., industrial engineering study of a freight car repair facility, 49
Speed, on curves, 501, 761
Spikes, track, high-carbon steel, specifications, revisions, 498, 761
Spirals, revision, 502, 761
Spraying right-of-way by helicopters, 576, 749
Standardization, panel discussion on, 764
Station buildings, portable, 192, 719
Stations, passenger, specifications, 188, 719

Statistics, and data processing, use in railway engineering, 234, 605
Steel surfaces, preparation and painting of, 296, 653
Stringers, glued laminated, laboratory investigation of static and repeated load strength, 302, 675
Structures, metallic, underground corrosion of, 354, 648
Structural plate pipe, specifications, advance report, 297, 653
Switch lamps and targets, reflex units for, 504, 761

T

Tampers, production, with automatic jacking and leveling devices, 274, 744
Tanks, steel storage, cathodic protection of, 108, 633
Tedesko, Dr. Anton, address, giant moonport structures take shape at Cape Kennedy, 663
Tellers, report of, 585
Texas & Pacific, treated ballast test, 572, 749
Tie renewals, cutting versus removing whole, labor economics of, 270
Ties and Wood Preservation, report and discussion, 225, 607
Ties, renewal statistics and costs, 780
—specifications, adherence to, 227, 608
  —possible revision, including spacing, 227, 608
  —standardization, 227, 608
Timber structures, repeated loading of, 302, 675
Track, report and discussion, 495, 761
—disturbed condition, investigation of, 551, 747
Track spikes, specifications, revisions, 498, 761
Trackwork plans, revisions, 499, 761
Trackwork, explosive hardening of, 504, 761
Transfer facilities, rail-water, planning, construction and maintenance, 171, 616
Transportation service, methods of analyzing the economics of railway engineering projects to improve quality of, 145, 711
Treasurer, report of, 595, 805
Trestles, prestressed concrete, specifications, revisions, 516, 662
—timber, preservative treatment, in-place, 304, 676
—wood, and bridges, design specifications, revisions, 300, 674
Truss bridge research project, 296, 653
Tunnel, replaced by through cut on the CNR, 559, 748

U

U. S. Public Health Service, relations with pertaining to railroad sanitary and servicing facilities, 106, 633
Universities (See Colleges)

V

Valuation and depreciation, current developments in connection with regulatory bodies and courts, 240, 606
Vegetation, chemical control of, 576, 749
von Kampen, K. H., panel discussion on standardization, 764

W

Water, for use in batteries, specifications, 126, 634
Water, Oil and Sanitation Services, report and discussion, 99, 631
Waterfront facilities, relative merits and economics of construction materials used in, 177, 616
Waterproofing railway structures, 323, 663
Waterway problems, use of hydraulic models for the study and resolution of, 170, 615
Waterways and Harbors, report and discussion, 167, 615
—bibliography, benefits and costs on inland waterway projects involving navigation, 168, 615
Watson, Stewart J., memoir, 497
Weed-control seminar, AAR, report of, 576, 749
Western Pacific, soil stabilization by chemicals, 547, 747
What price glamour, address, Dean W. L. Everitt, 697
Where do we go from here, address, R. R. Manion, 597
Weight-indicating and recording devices, scale, automatic, 137, 618
Williamson, H. M., panel discussion on standardization, 764
Wire, cable and insulating materials, specifications, 355, 648
Wiring diagrams, rolling stock, revisions, 340, 647
Wood Bridges and Trestles, report and discussion, 299, 674
—specifications for design, revisions, 300, 674
Wood, non-destructive testing of, 304, 676
Woolford, F. R., panel discussion on standardization, 764
Work equipment, alternators and transistorized electrical systems for, 281, 744
—snow removal equipment, 284, 744
—tamper, production, with automatic jacking and leveling devices, 274, 744

Y

Yards and Terminals, report and discussion, 127, 618
—foreign countries, present trends in modernizing of, 140, 620
Yards, piggyback, lighting for, 345, 648

ROOTS AND LOADS TIES

LAYING WELDED RAIL

9' WIDE TRACK CLEANING BUCKET

SPEED SWING

MODEL 441

Developed and Built
for Railroad Maintenance

180° BOOM SWING

DOES ALL JOBS!

LAYING STANDARD RAIL

CUTS MAINTENANCE COSTS

12 FAST CHANGE ATTACHMENTS

- Forks
- 1¼ Cu. Yd. Bucket
- Tote Hook
- 18' Boom Extension
- Fork Tie Baler
- Track Cleaning Bucket
- Back Hoe
- Clamshell
- Back Filler Blade
- Pull Drag Bucket
- 4 Cu. Yd. Snow Bucket
- Pile Hammer

Optional Attachment
Flanged Wheels, Hydraulically Controlled

PETTIBONE MULLIKEN CORPORATION

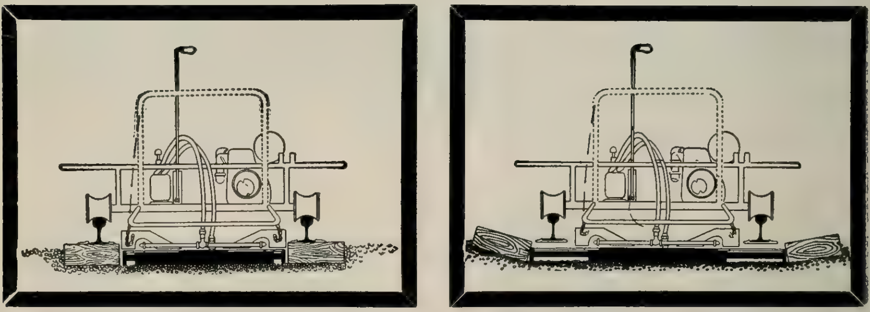
RAILROAD PMCO DIVISION
141 W. JACKSON CHICAGO 4, ILL.

80 Years of Service
to the Railroad Industry

Model N U Tie Cutter

HERE IS THE WINNING TEAM

The Woolery NU Tie Cutter and the Woolery Tie-end Remover preserve the line and surface of the track and at the same time reduce the cost of tie renewals. Ties can be removed without trenching, jacking up track or adzing tops of rail-cut ties. With this team you simply cut both ends of tie, pry out center piece, insert in its place the tie-end remover and out go the tie ends pushed by the double acting, double ended hydraulic cylinder of the Tie-end remover.



FOR HIGHEST EFFICIENCY USE TWO TIE CUTTERS WITH ONE TIE-END REMOVER

WOOLERY MACHINE COMPANY
MINNEAPOLIS, MINN.

New WELDED RAIL TRANSPORT

another development of NCG®... **LINK-BELT** teamwork in engineering and manufacture

CHECK THESE SERVICE PROVEN POINTS

- **Sturdy open-span construction—**
  for work saving feed-in;
  for picking up jointed re-lay rail; maintains best riding quality by keeping rails in original sequence for welding.
- **Positive double tie-down unit.**
- **Simplified low maintenance.**
- **Rollers life-lubricated.**
- **Hydraulically adjustable rollers and power-operated unloading equipment included.**
  One to six-tier units.

© 1963, Chemetron Corporation

NCG®

NATIONAL CYLINDER GAS
RAILROAD EQUIPMENT DEPARTMENT
Division of CHEMETRON *Corporation*

840 North Michigan Avenue, Chicago 11, Illinois

Instant
"Touch 'n Talk"
Communications

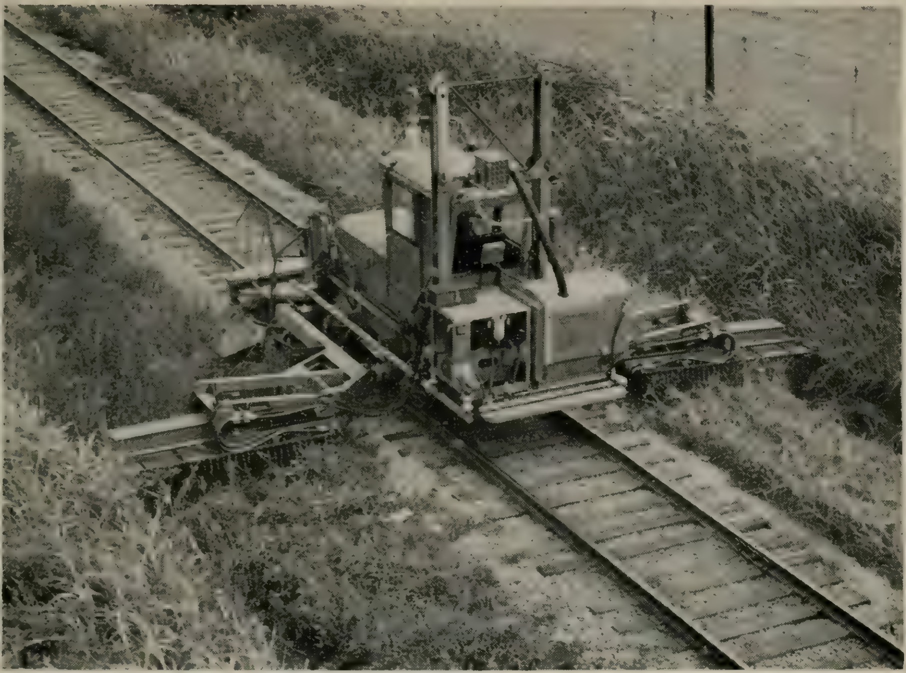
MOTOTOLA UNIVERSAL HT SERIES "HANDIE-TALKIE" PORTABLE RADIO

New convenience . . . new efficiency for the man-on-the-ground! With the industry's *lightest* (36 oz.) radio and a flexible accessory group, Motorola steps far ahead in providing "hands-free" portable radio operation. Always ready for action, the unit can be carried in the chest holder as shown, or clipped to the belt with the accessory speaker and microphone unit worn near the shoulder. *No need to handle the radio*—just press the mike button and talk! Call or write for full facts.

MOTOROLA
RAILROAD RADIO

Motorola Communications & Electronics, Inc., 4545 Augusta Blvd., Chicago, Ill. 60651. A Subsidiary of Motorola Inc.

KERSHAW Trackwork Machines



Weed And Brush Cutter (Track Patrol)
Designed, Tested, and Proven
on America's Railroads

KERSHAW
MANUFACTURING CO. INC
MONTGOMERY K ALABAMA

Trackwork Equipment Developed and Proven On the Job

Heavy Duty Ballast Regulator, Scarifier and Plow, Standard Ballast Regulator, Sacrifier and Plow, Track Broom, Super Jack-All, Standard Jack-All Kershaw Kribber, Two-Wheel Kribber, Tie Bed Sacrifier Tie Inseter, Track Undercutter-Skeletonizer, Ballast Cleaner, Crib-Adze, Mocar Crane, Track Crane and Tie Inserter, Utility Derrick, Two-Ton Rail Derrick, Tie Replacer, Dual Tie Saw, Track Liner, Snow Switch Cleaner, Weed and Brush Cutter (Track Patrol).

THE MATISA BNR-60

FASTEST TAMPING-LEVELING-LINING

precision: to 1/16 of an inch
speed: 1500 feet per hour
economy: one man operation; rugged construction—fewer breakdowns, fewer spares required

Raise track 6 inches (or as little as 1/16 of an inch) with a single pass of the BNR-60. Perfectly tamped, with the famous Matisa vibration-compaction principle.

Write or call for information on this most efficient, most extraordinary machine. Ask for data on leveling and lining track with the BNR-60.

MATISA
EQUIPMENT CORPORATION
1020 Washington Avenue
Chicago Heights, Illinois

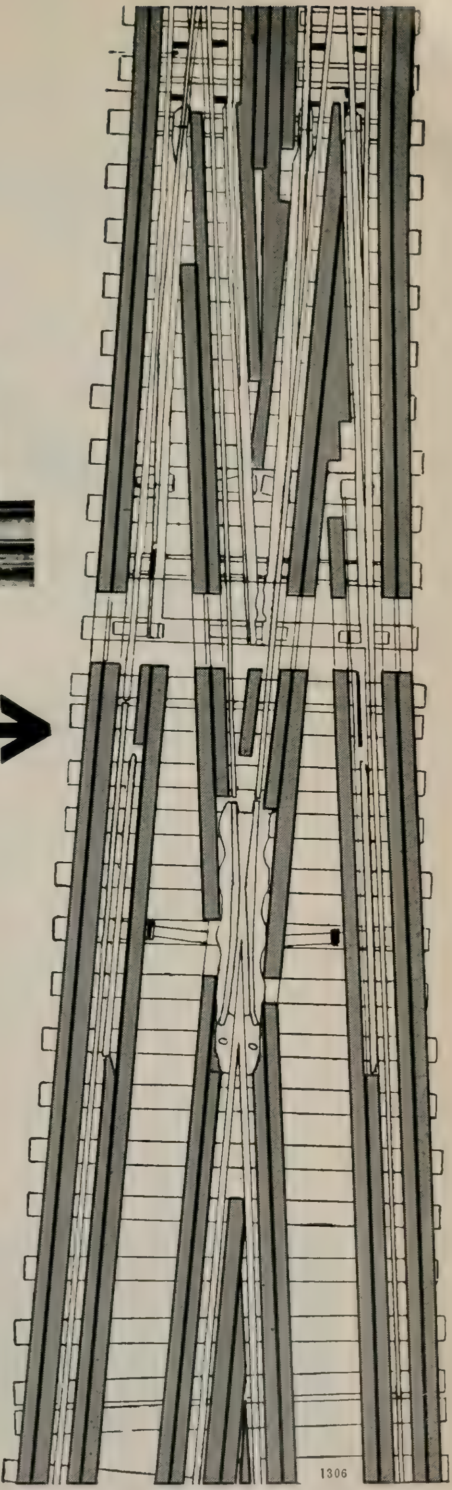
this is the **MATISA BUN-70**

. the only high production tamper-leveler for ANY and
LL track!

this is what it does when tamping switches, frogs,
close ties, etc.

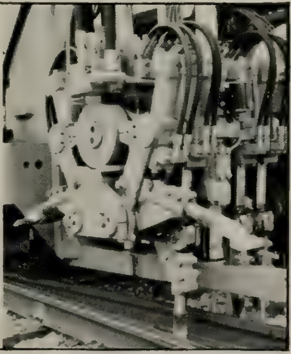
. . . perfect tamping at any
location marked in grey.

Also open track, of course, as a heavy-duty, high-production tamper-leveler.



this is how:

The same famous vibration-compaction tamping principle with 16 independent tamping tools. Each of these tools can be swung clear at will. YOU select the tools as operations require.

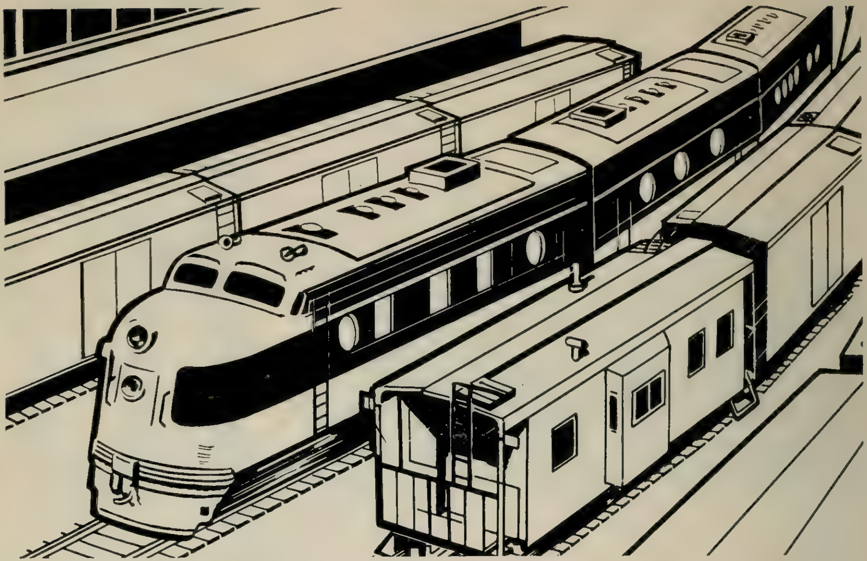


eveling, too!

Write for information on speed-precision-
epth tamping; leveling; lining, etc.

MATISA

EQUIPMENT CORPORATION
020 WASHINGTON AVENUE • CHICAGO HEIGHTS, ILLINOIS



UBIQUITOUS*

BARCOTE can be used wherever railroads run.

BARCOTE 325 and BARCOTE 600 as well as PROTECTIVE COATING 540 - 60 are products which have proven to be most satisfactory in the protection of metal surfaces. These products are compounded to withstand the elements, contamination and severe service.

Splice Bars, Rail and Rail Joints that are subjected to adverse conditions require the BEST in protection to obtain the optimum in service.

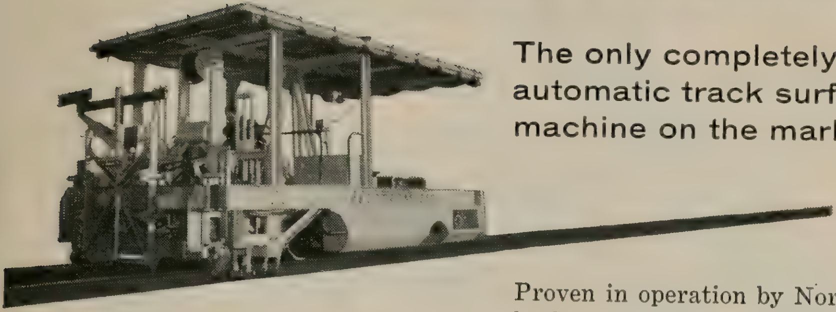
*Existing everywhere.

The BROOKS OIL Company
Established 1876

General offices and U.S. plant: 3304 East 87th Street • Cleveland 27 Ohio
Canadian offices and plant: 461 Cumberland Avenue • Hamilton Ontario

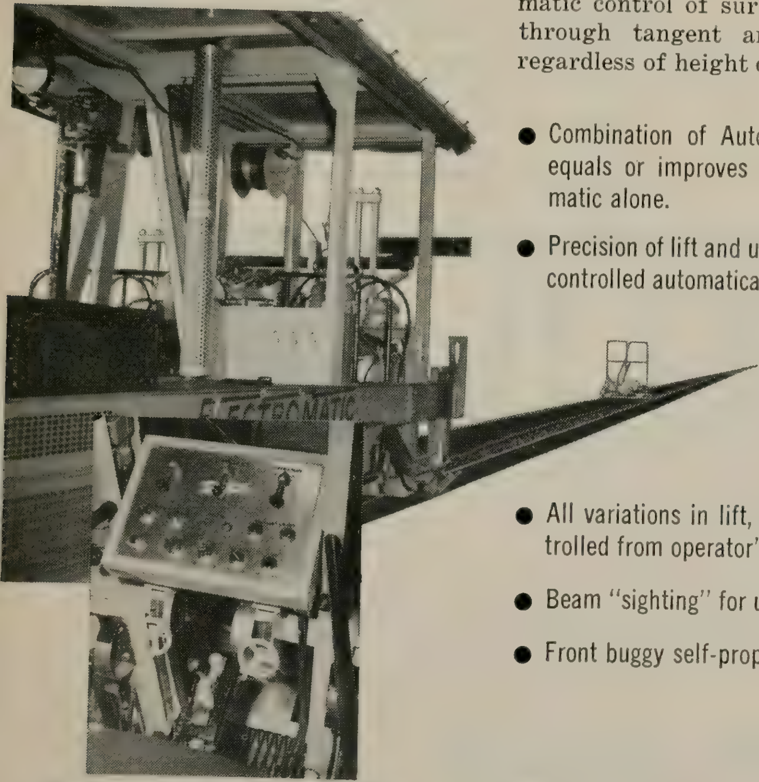
Tamper

AUTOJACK ELECTROMATIC



The only completely automatic track surfacing machine on the market

Proven in operation by North America's leading railroads. Complete and automatic control of surface and cross level through tangent and curve territory regardless of height of lift.



- Combination of Autojack and Electromatic equals or improves production of Electromatic alone.
- Precision of lift and uniformity of compaction controlled automatically.
- All variations in lift, level and run-out controlled from operator's panel.
- Beam "sighting" for utmost precision.
- Front buggy self-propelled ahead of tamper.

Tamper

TAMPER INC. 53 Court St., Plattsburgh, N.Y.

SALES AND SERVICE: 2147 University Avenue
St. Paul 14, Minnesota
Phone: 645-5055

IN CANADA 160 St. Joseph Blvd.,
Lachine (Montreal), P.Q.
Phone: 637-5531

Your enquiries for detailed information or brochures on Autojack Electromatic and other track machines are invited.

LT

LEE TURZILLO
CONTRACTING COMPANY

CONCRETE & MASONRY STRUCTURAL REPAIRS

BRIDGES, DAMS, POWERHOUSES
TUNNEL LINING REPAIRS
PRECAST AGGREGATE CONCRETE

FOUNDATIONS—UNDERPINNING

AUGERCAST PILES—FOUNDATION
STABILIZATION—PRESSURE GROUTING

BRECKSVILLE, OHIO—PHONE CLEVELAND 526-4391
OFFICES IN MAJOR CITIES

HYKIL WEED KILLERS

• Nationally Available! • Made-to-order!

Now . . . HYKIL Weed Killers are available from distribution points throughout U.S. Regardless of your local weed problem, HYKIL can solve it with a made-to-order weed killer and supply you . . . quickly and economically. Having years of experience in the field of specialized *railroad* vegetation-control, HYKIL can supply you with the correct aromatic, oil-based herbicide for your problem; can apply it for you under contract . . . using the finest equipment; or can build for your specific needs, the proper equipment to do the job.

Whatever your weed problem . . . call, write or wire for a quick solution.

W. T. Cox Company
INCORPORATED

1021 FRUIT STREET
SANTA ANA, CALIF.

580 WEST HIGHWAY 54
CAMDENTON, MO.

#2406

HYKIL

vegetation control
and
railway work equipment

AEROQUIP AIR HOSE...
THE 1 FOR 6
LOCOMOTIVE APPLICATIONS

That's Right . . . Aeroquip 1531 Air Hose is Number One for rugged service on six typical locomotive* lines: Signal, Main Reservoir and Sanding, Brake Pipe Actuating, and Independent Application and Release Lines. Why? Because Aeroquip 1531 Air Hose is quality designed and built for the job. Armored protection is provided by the wire braid reinforcement which is stainless steel in the 1⅜″ size. ■ Aeroquip 1531 Air Hose with reusable fittings is available in four sizes from ½ inch I.D. through 1⅜ inch. I.D. Operating pressure up to 300 psi, temperatures from −40° to +200° F.

*Also recommended for passenger car air lines

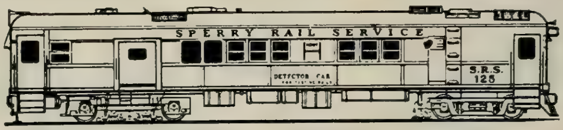
Aeroquip
REG TRADEMARK

AEROQUIP CORPORATION • JACKSON, MICHIGAN
INDUSTRIAL DIVISION
INDUSTRIAL PLANTS: VAN WERT, O.; BURBANK, CALIF.; DALLAS, TEX.; PORTLAND, ORE.; CRANBURY, N. J.; TUCKER, GA.
In Canada: Aeroquip (Canada) Ltd., Toronto 19, Ontario
In Germany: Aeroquip G.m.b.H., Baden Baden
AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A., CANADA AND ABROAD

THE DOUBLE U RAIL ANCHOR

ACHUFF RAILWAY SUPPLY CO.
ST. LOUIS, MO.

One complete service, One low charge



Each Sperry test car contains everything needed to test rail . . . induction equipment, ultrasonic equipment, motive power, crew and crew quarters. This self-sufficiency means a complete, unbiased test of each rail from end to end . . . a one-time operation that restores lines to normal traffic in minimum time.

Sperry service also provides reports, analysis, recommendations and comprehensive reviews. The one mileage charge pays for everything . . . equipment maintenance, car depreciation, statistical recording, accounting and operating costs. Sperry far surpasses every other rail service in research, efficiency and thoroughness, making its charge the lowest true cost per mile and per defect found. Details and technical assistance on request.

SPERRY RAIL SERVICE
A DIVISION OF AUTOMATION INDUSTRIES, INC.

General Offices DANBURY, CONN.

What's he doing?

Pumping Osmose "24-12" penta preservative solution into one of thousands of inspection holes.

Why?

To kill on contact all wood-destroying fungi and protect the adjacent healthy wood

that's what we mean by inspection and in-place treatment

OSMOSE

OSMOSE WOOD PRESERVING CO. OF AMERICA, INC.
980 Ellicott St., Buffalo, N.Y. 14209

WOODINGS-VERONA TOOL WORKS
Pioneer Manufacturers
of
HIGH GRADE TRACK TOOLS
and
SPRING WASHERS FOR TRACK
Since 1873
VERONA, PA. CHICAGO, ILL.

WOODINGS FORGE & TOOL COMPANY
Makers
of
WOODINGS RAIL ANCHORS
VERONA, PA. CHICAGO, ILL.

P. O. Box 10378
Area Code 305
LOgan 6–7922

GREENHEART, INC.
1431 N. E. 26th Street
FORT LAUDERDALE, FLORIDA

President—John L. McEwen—Quarter Century Experience

IMPORTERS:
GREENHEART—3300F Piles, Lumber, Timbers Long Length
MORA EXCELSA—Lumber and Timbers
MANBARKLAK—Piles
ANGELIQUE (Basra Locus)—Piles, Lumber and Timbers
and other Woods from
Burma, Siam, Australia, Africa and South America
Data furnished on request

MECHANICAL
MUSCLES®

Use these NORDBERG *Mechanical Muscles*® to cut Maintenance Costs

- Self-Propelled Adzer
- Ballast Router
- Ballastex®
- Cribex®
- DSL Yard Cleaner
- Dun-Rite® Gaging Machine and Bronco
- Gandy® Tie Puller and Inserter
- Gandy-Snapper
- Line Indicator
- Midget Surfacer
- Midget Line Indicator
- Power Jack
- Power Wrench
- Rail Drill
- Rail Grinders
- Rail Lifter
- Scarifier-Inserter
- Screenex®
- Spike Hammer
- Hydraulic Spike Puller
- Mechanical Spike Puller Self-Propelled
- Surf-Rail Ⓣ Grinder
- Switchliner
- Tamping Power Jack
- Tie-Axe
- Tie Drill
- Tie Spacer
- Trakliner®
- TrackShifter
- Trak-Surfacer

NORDBERG

NORDBERG MFG. CO.,
MILWAUKEE, WIS. 53201

©1965, N.M.CO.

R265

Hubbard Super Service Alloy Spring Washers
Hubbard Super Steel Alloy Spring Washers
Hubbard Track Tools

Hubbard Tool Division
UNIT RAIL ANCHOR CORPORATION
New York Pittsburgh Chicago

Unit Rail Anchor

UNIT RAIL ANCHOR DIVISION
UNIT RAIL ANCHOR CORPORATION
NEW YORK PITTSBURGH CHICAGO

NEW and RELAYING

RAIL
Switch Material · Tools
Track Accessories

PILING
Rental Steel-Sheet Piling
Pipe Pile · H-Bearing Pile

PIPE
Tested and Structural
All Sizes 1/8" thru 48"
Valves, Fittings, Flanges

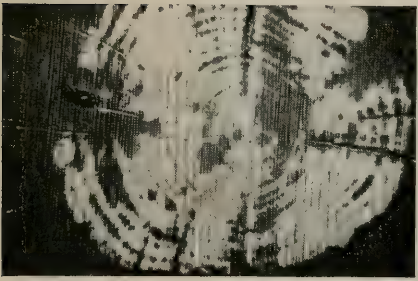
Immediate delivery
from Foster's nationwide
warehouse stocks.

Specialists to the Railroads

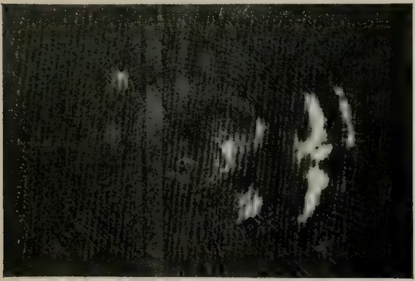
L. B. FOSTER co.

Pittsburgh
Cleveland
Los Angeles
San Francisco
Atlanta
New York
Chicago
Detroit
Houston
Orlando

Shell introduces a new wax that saves railroads money



Conventional preservative applied under commercial pressure-treating procedures penetrated only partway into this red oak tie. Center is vulnerable to rot and water.



SHELLWAX WT was mixed with the same preservative and applied under the same pressure to another red oak tie. Note enormous increase in penetration.

For every mile of track, your railroad probably spends $220 a year or more replacing cracked and rotted ties. A new Shell product, SHELLWAX® WT, can help you reduce tie replacement costs. Mix it with conventional preservatives and it enables them to do a better job. This is how:

1. SHELLWAX WT reduces cracking and swelling by slowing seepage of water into and out of ties.

2. SHELLWAX WT gives better protection by penetrating deeper into wood than conventional preservatives alone.

3. SHELLWAX WT protects ties longer by reducing the loss of conventional preservatives due to weathering.

Send for report

For a detailed technical report on new SHELLWAX WT, write to Shell Oil Co., Railroad Sales Dept., Room 3844, 50 W. 50th St., N.Y., N.Y. 10020.

SHELL

GEARED TO PROGRESS
P R I
MEMBER

AREA Publications—Price List

The following include some of the Association publications available from the secretary's office on order. Prices shown are for Members only:

	Member Price
Manual of Recommended Practice, complete in 2 volumes, including binders (first copy)	$18.00
Extra binders, each	4.50
Annual Supplements (first copy)	1.00

Separate Chapters

1–Roadway and Ballast	1.50
3–Ties	.25
4–Rail	.75
5–Track	.75
6–Buildings	1.50
7–Wood Bridges and Trestles	1.00
8–Masonry	1.00
9–Highways	0.50
11–Engineering and Valuation Records	1.25
13–Water, Oil and Sanitation Services	1.00
14–Yards and Terminals	1.00
15–Iron and Steel Structures	1.25
16–Economics of Railway Location and Operation	0.75
17–Wood Preservation	.50
18—Electricity (AAR Electrical Manual, $23.00 Complete with binder. Separate Sections available, prices on request)	
20–Contract Forms	1.25
22–Economics of Railway Labor	0.50
25–Waterways and Harbors	0.25
27–Maintenance of Way Work Equipment	0.50
28–Clearances	0.25
29–Waterproofing	0.25
Flexible-cover, loose-leaf binder for separate chapters, each	0.40

Portfolio of Trackwork Plans–119 plans, 8 sheets of specifications, 5 sheets definitions of terms, complete with leatherette cover	$12.50
Track Scale Pamphlet–109 pages, flexible cover	1.00
Federal Valuation of Railroads–87 pages, flexible cover	1.00
Instructions for Mixing and Placing Concrete–24 pages, flexible cover	0.40
Handbook of Instructions for the Care and Operation of Maintenance of Way Equipment–149 pages, hard cover	0.85
Instructions for Care and Safe Operation of Welding and Grinding Equipment–23 pages, flexible cover	0.30
Specifications for Steel Railway Bridges (fixed spans)–70 pages, flexible cover	0.75
Specifications for Movable Railway Bridges–73 pages, punched sheets	1.00

PROVEN

In Service!

- **RAIL ANCHORS**
  Compression Rail Anchors
  Compression Bridge Tie Anchors

Rail-Tel Switch Heater

Automatic Switch Point Lock

- **SWITCH HEATERS**
  Rail-Tel (Gas)
  Elec-Time (Electric)
- **AUTOMATIC SWITCH POINT LOCK**
- **TRACK LUBRICATOR**
- **SNOW DETECTOR and Switch Heater Controller**

If you haven't discovered Rails Co. Products . . . Investigate them today! Write, wire, phone for information.

The RAILS Company

187 Maplewood Ave., Maplewood, N. J.
Offices: St. Louis, Mo., Chicago, Ill.

P. & M. PRODUCTS

- IMPROVED FAIR Rail Anchors

RAIL JOINT PRODUCTS

- Rajo Joints
- Insulated Joints
- Compromise Joints
- Fibre

MAINTENANCE EQUIPMENT PRODUCTS

- Meco Rail and Flange Lubricators
- Meco Rail Layers
- Meco Brush Cutters
- MACK Reversible Switch Point Protectors

PEERLESS EQUIPMENT PRODUCTS

- Draft Gears
- Rail Titan Batteries

IN CANADA:
The P. & M. Company Ltd..

552AB

PRODUCTS OF PROGRESS

POOR & COMPANY
Railway Products Division 80 E. Jackson Blvd., Chicago 4, Ill.

Assure lower maintenance costs, better performance with...

TEXACO

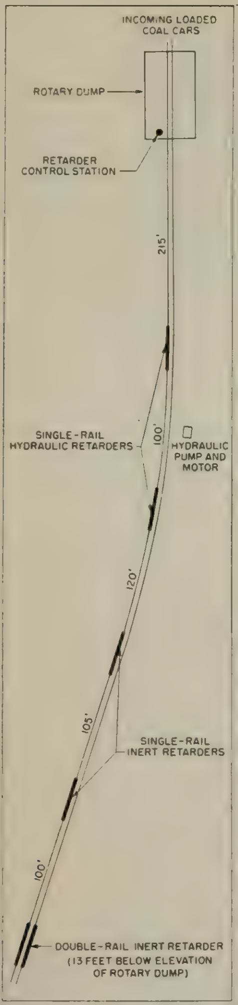
Petroleum Products and Systematic Engineering Service

TEXACO

TEXACO INC.
RAILWAY SALES DIVISION
135 East 42nd St., New York 17, N. Y.

NEW YORK • CHICAGO • SAN FRANCISCO • ST. LOUIS • ST. PAUL • ATLANTA

We can help you control railroad cars the ECONOMATIC way.


INCOMING LOADED COAL CARS
ROTARY DUMP
RETARDER CONTROL STATION
215'
SINGLE-RAIL HYDRAULIC RETARDERS
100'
HYDRAULIC PUMP AND MOTOR
120'
105'
SINGLE-RAIL INERT RETARDERS
100'
DOUBLE-RAIL INERT RETARDER (13 FEET BELOW ELEVATION OF ROTARY DUMP)

Why should you have to learn all the tricks? That's what we're here for.

We've come up with several products that can make car handling a far easier job.

Like hydraulic retarders that slow cars down or stop them completely. Yet all you need is one man in a control room, pushing buttons.

Like switch machines that can be thrown three ways. They're remote controlled, manual—or can be thrown by a trailing movement of the train.

Like the world's most complete line of special products for your in-plant railroad: such as frogs, switches, crossings, lubricators, spike drivers and many more.

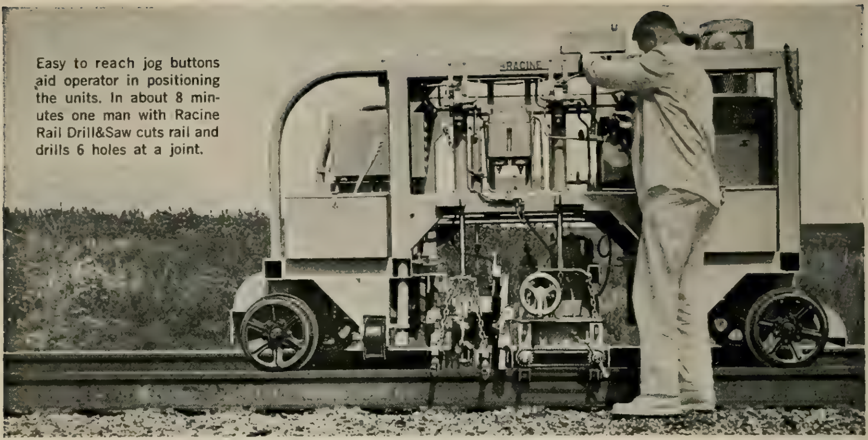
Once we go over your car control job with you, we may come up with suggestions for substantial savings, in manhours and money.

All we ask is a chance to show you.

Check with your Brake Shoe man, or write Railroad Products Division, 530 Fifth Ave., N.Y. 10036. In Canada: Dominion Brake Shoe Company, Ltd.

AMERICAN
Brake Shoe
COMPANY

Typical Economatic Car Handling System. This uses a series of Brake Shoe Retarders to control descent of empties, eliminating car riders and increasing both the speed and the safety of car handling.



Easy to reach jog buttons aid operator in positioning the units. In about 8 minutes one man with Racine Rail Drill&Saw cuts rail and drills 6 holes at a joint.

UP TO 21 INSULATED JOINTS PER DAY

The Racine Rail Drill&Saw, equipped with a multiple 3 spindle drill and hydraulic feed reciprocating saw, is a dual-purpose, single operator machine for cutting-in insulated joints or cropping rail in track.

Up to 21 insulated joints per day in ribbon rail have been completed by a single machine, using the following sequence of operations:

(1) Saw rail and drill 6 holes.
(2) Expand joint with Templeton-Kenley Hydraulic Expander.
(3) Insert end post.
(4) Assemble angle bars (using electric impact wrench).

The 3 spindle drill unit may be pre-set to bore two or three holes on 5½" to 7" centers. Hole center adjustment is made by inserting solid spacer blocks, forming a "fixed" center drill head.

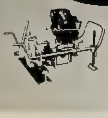
The saw unit is a new concept for reciprocating rail saws. Accurately controlled hydraulic feed pressure is used to cut rail consistently fast and straight. Blade cost is only a few cents per cut.

The machine is basically a self-propelled carriage and power plant for mounted saw and drill units. It is also available in various combinations of saw and drill units to suit your needs for in-track rail cropping operations. Electrical outlets on the machine give you plug-in power for impact wrench, drill bit grinder, work lights or other portable tools.

Write for more information today: Racine Hydraulics & Machinery, Inc., Dept. B95, Racine, Wisconsin. RR-150

RACINE

Unit Tamper

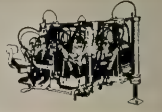


Portable Rail Drill

Portable Rail Saw

Anchor Applicator

Rail Drill&Saw

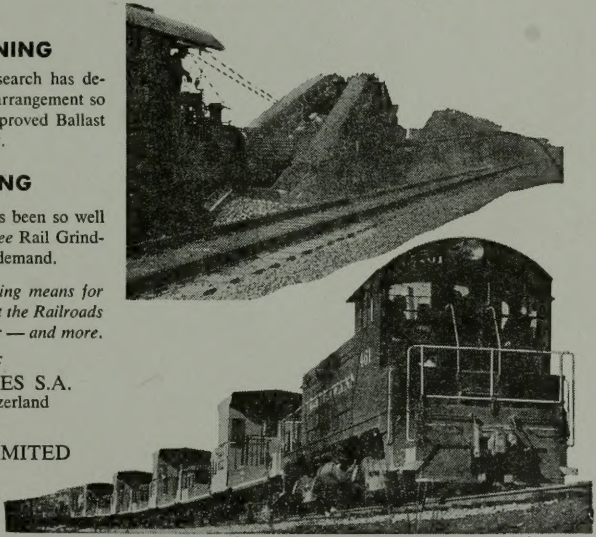


Production and Spot Tampers

PROGRESS REPORT

SPENO

Here are the up-to-date facts on the SPENO Ballast Cleaning and the SPENO Rail Grinding Services.



BALLAST CLEANING

SPENO Engineering and Research has developed a superior screening arrangement so that we are now using an improved Ballast Cleaner with greater efficiency.

RAIL GRINDING

Our Rail Grinding Service has been so well received — we now have *Three* Rail Grinding Trains to take care of the demand.

SPENO is constantly developing means for better service to make sure that the Railroads receive everything they pay for — and more.

Outside North American continent:

SPEMA RAIL SERVICES S.A.
Grand-Pont 2, Lausanne, Switzerland

Canadian Sales Representatives:

THE HOLDEN CO. LIMITED
614 St. James St., West
Montreal, Canada

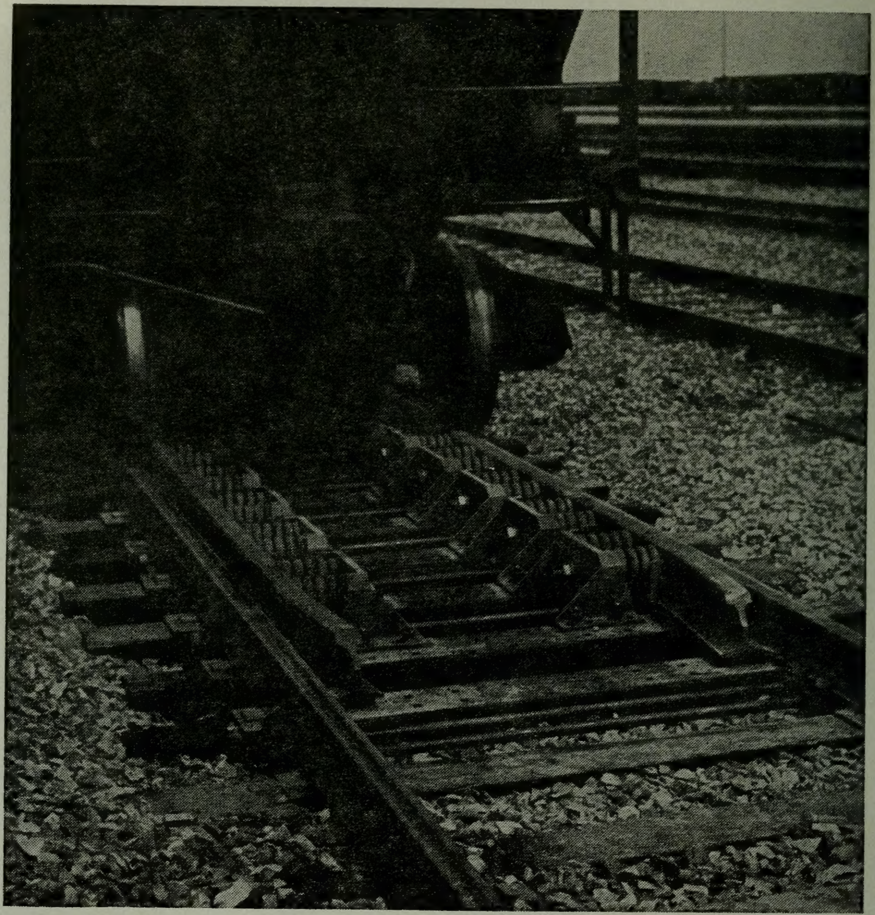
Just Ask the Railroads That have used us!

GEARED TO PROGRESS
PRI
MEMBER

FRANK SPENO RAILROAD BALLAST CLEANING CO., INC.

Clark Street
East Syracuse, N. Y.

306 North Cayuga St.
Ithaca, N. Y.



THE TRASCO CAR RETARDER

HUNDREDS IN SERVICE
IN CLASS YARD TRACK

TRACK SPECIALTIES COMPANY
P.O. BOX 729 WESTPORT, CONNECTICUT

965